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The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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The Three Fields

The thoughts of many are at the moment directed towards the popularisation of castings, in order that the foundry industry may progress. In this connection it is interesting to divide castings into their various groups and then subdivide them into three categories. The first category comprises those goods which have an unassailable position in the field they serve, because of a combination of price and inherent qualities. This field is more limited than one would believe, and if major alterations in primary design are envisaged, it may be assailed. Outstanding for cast iron are ingot moulds for steelworks, motor-vehicle cylinder blocks, firebars and sash weights. Ingot moulds for non-ferrous use, however, have been made of copper, and the most modern design of windows dispenses with sash weights. There is, therefore, a warning that although the position may seem impregnable for an industry it is essential that efforts be made to improve on existing practice.

The next category is where the cast product is subject to competition from non-foundry materials. In this case it is easier and more illuminating to dwell on processes rather than actual components or finished entities. Drop forging, steel pressing, weldings, plastics, steel-pipe manufacture, and the ceramic industry are all actual or potential competitors. It is significant to note that to overcome these phases of competition the founder has to develop entirely different properties in each case. Sometimes it is æsthetic appearance, sometimes strength-weight ratio, or maybe resistance to heat or corrosion of various types. That efforts are being made is strikingly illustrated by the fact that 10 per cent. of America's very considerable production of cast iron is now alloyed, and probably a similar ratio is maintained in this country.

The last category is the most interesting of all, and relates to the replacement of non-foundry productions by castings. The most interesting recent development is that of the cast crankshaft, as it points the way for further encroachment on the field hitherto exclusively held by steel forgings. For many decades, designers have assumed that whilst cast iron is satisfactory for static components, steel must be used for those involving dynamic stresses. Here the property to be developed is that of "damping" stresses so as to inhibit their concentration. There is indicated yet another promising field, and that at the expense of the steel founder. We refer to the entry of cast iron into wear-resisting fields. Here, modern cast irons are found to be replacing parts normally made from manganese steel.

Castings, both ferrous and non-ferrous, are so diverse in character that balanced research work of a fundamental character is essential. Work designed to help founders to compete with forgings is not likely to be of great help in overcoming the competition from plastics. To popularise cast iron by propaganda, as is being suggested, needs a profound study of the situation from the three angles we have suggested, and concentration must be devoted to the second category.

Government Expenditure Praised

It is so common to find Government expenditure, raised by taxation, criticised and the objects of such expenditure regarded with suspicion that it is unusual to find a Government department whose costs are hailed with uniform satisfaction and by whom higher expenditures would be welcomed. Yet this is what happens each year to the Department of Scientific and Industrial Research. The Department is under the Privy Council and is advised by a body of eminent scientists, of whom Lord Riverdale of Sheffield has been elected chairman to succeed the late Lord Rutherford. The Department administers the national laboratories such as the National Physical Laboratory, the Geological Survey and Museum and the Fuel Research Station, as well as providing grants to the score or so research associations, which are, of course, also supported by industry. There is scarcely any department of the national life into which the work of the Department in one way or another does not penetrate; food, fuel, boots, clothes, touch the citizen as closely as the industrialist. The foundry industry has a direct concern in the three associations dealing with the metal industries, the British Cast Iron Research Association, the British Non-Ferrous Metals Research Association and the Iron and Steel Industrial Research Council, while the work of the bodies connected with automobile engineering, refractories and electrical engineering have an obvious interest for it. As one leading paper put it, "The man in the street—and, for that matter, the manufacturer of balanced view—will probably be surprised at the smallness of the expenditure, relative to the results which have accrued." For the Government and industry combined pay something like £370,000 per annum, and it is added that "it is to be hoped therefore that the Advisory Council of the Department will find every industry reasonably acquiescent in any suggestion for intensified research, when later in the year it comes to review the whole scheme of grant-aided research associations."

Correspondence

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Calcium Carbonate Inclusions in Moulding Sand

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—It appears to be understood generally that free calcium carbonate, in the form of limestone or chalk, occurring in moulding sand is detrimental. Preliminary experiments in order to justify this opinion indicate that when the inclusions are in a finely divided state, no disadvantage is apparent.

I should be very grateful to learn from practical experience in steel and iron moulding whether any conclusions have been drawn on this subject.—Yours, etc., E. J. CRAWLEY.

General Refractories, Limited,
Genefax House, Sheffield, 10.
February 2, 1938.

Custom of the Trade

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In the issue of THE FOUNDRY TRADE JOURNAL of January 20, on page 80, the last portion of the letter signed "Foundryist" is misleading.

If the last sentence—"Actually this is not a trade custom, but well established law"—were true, there would be necessity for drastic revision of prices for castings which had to be machined, as no foundry could bear the responsibility without increasing the cost of the castings by means of a premium against liability for machining costs.—Yours, etc., "ECOSSAIS."

February 3, 1938.

Antiquity of Cast Iron

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In your leading article in the JOURNAL for February 3 you make interesting references to the early iron castings in China, and I would suggest that it would be very useful if someone would present these studies in an easily accessible form.

There is one point in which I suggest you have unwittingly given a wrong impression in referring to the origin of iron casting being in China. Whilst priority is always interesting, I have always felt that the various discoveries connected with iron and steel have been made quite independently in all countries. In other words, that mankind, faced with the same problem of dealing with material, has solved the matter in accordance with natural laws without the idea or the method having been passed on. There is no reason to think that the ancient Chinese art was passed on to other countries, although there is some evidence that steel for the manufacture of the well-known superb Japanese swords was sometimes imported from China and Korea. The wonderful weapons made in Japan from A.D. 900 onwards were mostly produced from local materials, and the art was kept strictly local, apart from specimens being taken to other countries following piratical episodes. Dr. Lardner refers to Japanese sabres in his Encyclopædia, 1832. "Marksman" also alludes to firebacks, etc., and while these interesting and beautiful castings are probably the earliest specimens of iron casting in Europe, they were nevertheless probably of independent discovery, that is, without extraneous ideas having contributed to the method.

Difficulties of travel and language prevented ideas spreading, apart from specimens being passed from hand to hand by war and looting. The iron castings in the Stahlhaus at Düsseldorf are well worth a foundryman's visit, and some day the Chinese specimens may be on view! Did Marco Polo make reference to any iron castings?—Yours, etc., A. ALLISON.

Holmes Mills, Rotherham.
February 5, 1938.

Book Reviews

Ryland's Directory. 24th edition. Published by "The Iron and Coal Trades Review," 49, Wellington Street, London, W.C.2. Price, £2 2s. cloth bound; £2 12s. leather bound.

The object of a trade directory is to supply information of a commercial character pertaining to an industry or group of industries, and the success with which any such publication meets will be judged on the dual grounds of the anticipation of what is considered to be useful commercial information and its presentation. The editors of Ryland's Directory, with 48 years' experience to draw upon, have decided that the two cardinal features must be aids to buying and selling. Taking the former aspect first, the directory details, in addition to lists of the manufacturers of almost every conceivable commodity used by the heavy industries, including, of course, that of foundry work, pages devoted to technical descriptions of the pig-irons available to the industry, the standard sections of steel components rolled by the various works, and the dimensions of steel sheets normally produced. For the sales department, it is obvious to the intelligent executive that the same lists are of equal importance. If a steel founder is selling manganese steel plates to one manufacturer of sand mills, then Ryland's discloses that there is a market for his goods amongst that customer's competitors. Sales managers require additional information, such as telegraphic addresses, trade marks, the existence of employers' federations, the density of markets in any one area, the capital and directorate of the works to which he sells, and the dividends which they have paid in recent years. All this information is contained in the Directory, and what is more, it is so intelligently indexed that a junior can readily procure any information desired. It is perfectly true to state that we can answer 80 per cent. of the 1,500 or more commercial inquiries we receive in the course of a year by reference to our copy of Ryland's. It would be no compliment to the editors to say that new features have been incorporated for this new edition, and the best that can be said is that all the existing features have been retained and brought up to date. New features are more often than not an excuse for past lapses. To our mind Ryland's is an indispensable article of commercial equipment for the office of any industrial organisation connected with the iron, coal and foundry industries.

V. C. F.

Locomotive Engineers' Pocket Book. 38th edition. Published by the Locomotive Publishing Company, Limited, 3, Amen Corner, Paternoster Row, London, E.C.4. Price 3s. 6d.

This interesting pocket book undoubtedly appeals to a wider public than that strictly associated with the construction and running of railway locomotives, for not only are the spectacular performances detailed, but a directory of locomotive-using firms is included. Very little is said about the materials of construction, and only one short table of tensile strengths is given, so that founders can regard this book much as the layman would. The reviewer found it very interesting from this aspect.

Manchester Association of Engineers

The annual dinner and dance of the Manchester Association of Engineers will be held on Friday, March 4, at the Grand Hotel (Jubilee Suite), Aytoun Street, near Piccadilly, Manchester. The dinner dances held during the last three years have been so successful that the Council have decided this year the annual dinner will also be followed by dancing, and ladies are invited. There will be no speeches with the exception of the toast of the President. Application for tickets (9s. 6d. each, exclusive of wines) should be addressed to the Secretary, Mr. T. Mckemson, St. John Street Chambers, Deansgate, Manchester, 3.

Random Shots

A certain foundryman, finding himself with a "dasty bad cold in the dose" betook himself to bed. A good opportunity, thought he, to get up to date with his technical reading. The fever not abating after the first day, he lay there a second and a third, and, being a very good foundryman, his mind still concentrated on the more obscure problems of metallurgy long after he had devoured all his literature. Eventually, he tired of thinking around his work and gave himself over to the delicious extravaganzas of the Arabian Nights, thinking therein to indulge in a complete mental change.

* * *

No sooner had he read a few pages when behold! an aged fisherman cast his net into the sea and dragged out a heavy vase of "yellow" copper, shut up and fastened with lead. "I will sell this to a founder" said he with joy. "Scrap merchant" murmured the invalid, involuntarily correcting the ignorant fisherman. Still undaunted by this rude reminder of his work, he read on and on, entranced with the adventures of enchanted princes and princesses. Then there came a story of one Agib, son of a Sultan, who went on a long voyage and was overtaken by a terrible disaster. Sailing towards an ominous-looking black mountain, his ship was involuntarily attracted towards it. All the nails and iron on this ship flew towards the mountain, where they fixed, by the violence of the attraction, with a horrible noise. This wretched "mountain of adamant" could be nothing more or less than a lump of magnetite, thought the fever-stricken foundryman, and his mind got busy once again with the problem of cast magnets. "A plague on the metallurgical mind," he screamed as his scientific eye watched the sudden rise in his temperature.

* * *

The doctor came and prescribed an iron tonic, to be followed by a week's holiday playing on the sands at Torquay. . . . That doctor was found dead on the floor, cut in two by a stainless knife, and when that poor foundryman recovers from his surprise and dismay he will have to face a charge of "Murder with malice aforethought."

* * *

Let this be a warning to all those who have stands at the British Industries Fair this year, to take very extra special precautions against catching that annual cold!

* * *

There were sounds of revelry at night in Jewry Street, London, on Saturday, when the Metallurgy Department of the Sir John Cass Technical Institute held its annual dance. "Marksman" enjoys this function quite as much as the more pretentious "hops" of the senior institutes. As all dances should, it went with a swing from the start. "Marksman" regretted the omission this year of the students' stage entertainment, but Mr. W. E. Hoare, forsaking research work on tinplate that evening, appeared as vocalist, and the songs which he (and the gathering) sang were full of sly digs at everybody connected with the Metallurgy Department, from Principal Patch. to the lab. boys. The lecturer in foundry practice was not spared, for he was accused of making his castings in mud (mainly because of the exigencies of rhyme). A word of praise has to go to those who organised this very successful evening.

"MARKSMAN."

Refractories Film Show

Various films showing the manufacture and use of refractories made by General Refractories, Limited, were shown at the company's London offices at Russell House, Adam Street, Adelphi, on Friday, January 28. The programme, which lasted about two hours, was interspersed with some non-technical reels.

The Metallurgy of Cast Iron*

By A. E. PEACE and P. A. RUSSELL, B.Sc.

Introduction

In considering the preparation of this Paper, the authors had difficulty in deciding how much ground to cover and how to apportion the work. The usual method of approach to the subject is academic, using the well-established iron-carbon diagram as a starting point. However, an entirely opposite method of attack was decided upon which, it is thought, will prove of greater interest, will better correlate the practical and academic aspects and will enable the authors to select material to present to best advantage under these conditions.

Certain physical properties will be chosen, one or other of which is a requisite of all good-quality iron castings, and the factors which affect them will be dealt with. The chosen properties are hardness, strength, pressure tightness, general soundness and heat-resistance.

PART I

By A. E. PEACE.

It is proposed to consider the property of hardness as broadly understood and not critically to define it by discussion of wear resistance, machinability and the like. For this purpose hardness is the property revealed by indentation tests such as the Brinell.

Cast iron is now produced with an exceptionally wide range of hardness, approximately from 100 to 1,000 Brinell. The extreme variation capable of attainment is the result of metallurgical research during the last few years. Iron castings are now performing duties impossible to the metal five to ten years ago, and in many other instances are giving far superior service to that which was considered normal.

Hardness is affected by: (1) chemical composition; (2) raw materials used, *i.e.*, pig-iron, scrap and steel; (3) melting conditions; (4) thermal conditions, *i.e.*, from spout to cooled casting, and (5) heat-treatment.

Items (2) and (3) will not be considered, as a future lecture on melting practice will probably deal with them.

The notable influences on hardness of chemical composition are brought about in three different ways. The first and most important is by the effect on the various forms of carbon. The second is the effect of elements forming solid solutions in the iron, and the third the effect of elements forming distinct structural components.

The softest cast iron, shown in Figs. 1 and 2, is that containing no combined carbon, wherein the structure is ferrite and graphite. In ordinary grey iron, shown in Fig. 3, the combined carbon is in the form of pearlite. This is alternate lamellæ or layers of ferrite (carbonless iron) and cementite (the carbide of iron), approximately six parts of ferrite to one of cementite. The ferrite is very soft (about 100 Brinell), and the cementite is extremely hard (about 700 Brinell). The hardness of pearlite is around 200 Brinell.

In a white iron the hardness is greater with larger amounts of free cementite. Since pearlite has a definite composition, increase in total carbon in a white iron results in increase of free cementite, and hence greater hardness. Note the greatly increased amount of free cementite in Fig. 5 compared with Fig. 4.

Inducing Maximum Hardness

Additional hardness is only now obtainable by alteration of the pearlitic matrix. To explain this it is necessary to go more fully into the iron-carbon system.

In molten cast iron the carbon is present as the carbide, cementite, and is in solution. In the solid state cementite is only partially soluble, so that when molten cast iron freezes part of the cementite remains in solid solution, and the remainder is rejected as free cementite. This solid solution formed on freezing is austenite, and at this temperature, about 1,130 deg. C., the saturated solution contains around 2 per cent. of carbon. The solubility decreases as the temperature falls, so that on cooling from the freezing point more and more cementite is rejected, until at about 730 deg. C. the austenite only contains some 0.9 per cent. of carbon. Below 730 deg. C., cementite is insoluble in the iron, so that at this temperature the austenite is transformed and the cementite is precipitated in the form of laminations in the ferrite, as seen in the illustration showing the pearlite structure.

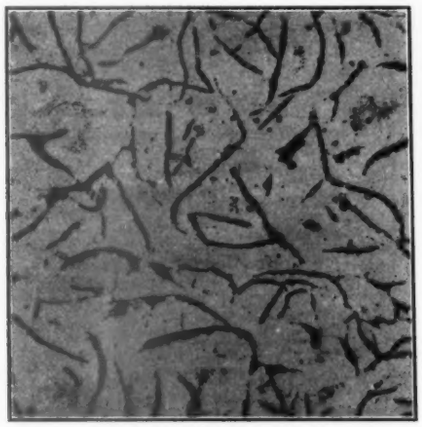


FIG. 1.—GREY CAST IRON. FERRITE AND FLAKE GRAPHITE. × 200.

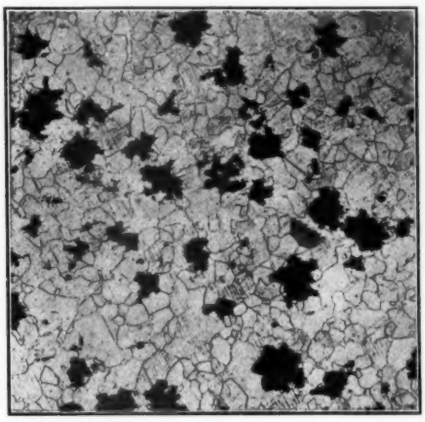


FIG. 2.—BLACKHEART MALLEABLE CAST IRON. FERRITE AND NODULAR GRAPHITE. × 50.

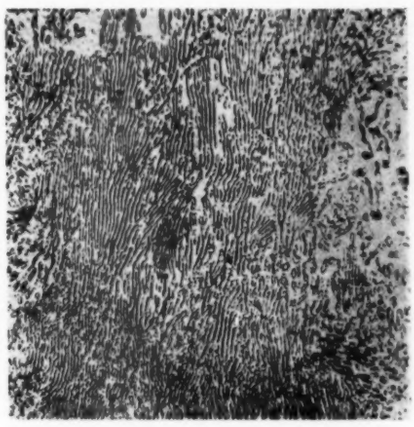


FIG. 3.—PEARLITE. × 600.

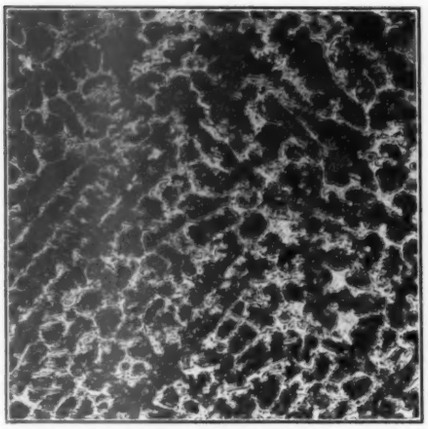


FIG. 4.—WHITE CAST IRON, 2.5 PER CENT. T.C. PEARLITE AND CEMENTITE. × 50.

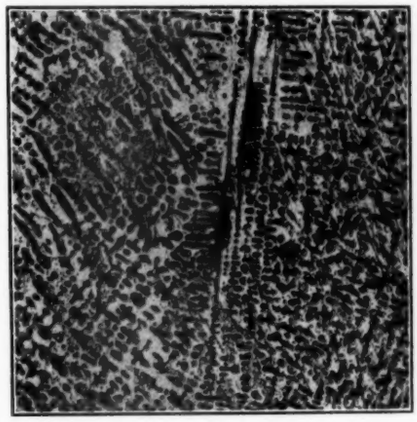


FIG. 5.—WHITE CAST IRON, 3.3 PER CENT. T.C. PEARLITE AND CEMENTITE. × 50.

FIG. 6.—AUSTENITE AND GRAPHITE. × 500.

* Paper read before the East Midlands Branch of the Institute of British Foundrymen.

This transformation can be prevented to varying degrees by drastic cooling and alloying. If the change is completely prevented the structure is austenite with a hardness but little above that of ferrite. This is shown in Fig. 6.

If the change be only partially restrained, then martensite is produced which may be regarded as a decomposition product of the austenite. Fig. 7 shows martensite in a grey cast iron, and Fig. 8 in a white cast iron.

Martensite is intensely hard, about 650 Brinell, and this matrix structure with cementite gives the hardest cast iron obtainable, except for the surface hardness gained by nitriding, which reaches 1,000 Brinell.

FIG. 7.—MARTENSITE AND GRAPHITE. × 500.

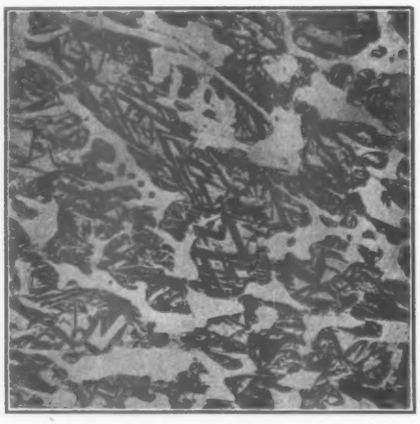


FIG. 8.—MARTENSITE AND CEMENTITE. × 260.

EFFECT OF THE ELEMENTS ON THE VARIOUS FORMS OF CARBON

Carbon

The amount of carbon which can be dissolved in molten iron is greater the higher the temperature, and the amount which can be held in solution at the freezing point, known as the eutectic quantity, is 4.3 per cent. in a pure iron-carbon alloy. In a hyper-eutectic alloy (*i.e.*, with carbon content above the eutectic amount) when cooling down to the freezing point the excess carbide is precipitated. The carbide at these temperatures is very unstable and easily dissociates into iron and graphite, so that hyper-eutectic irons are liable to be highly graphitic. Below the freezing point the carbide rejected by the austenite as previously explained will still graphitise, but less readily as the temperature falls, until below 730 deg. C. the carbide is stable and will not break down.

Graphite softens an iron, although the effect is largely masked by the greater effect of the state and amount of combined carbon.

Silicon

Silicon lowers the eutectic carbon by about 0.3 per cent. for every 1 per cent. of silicon, so that with high silicon content there is likely to be a greater excess of cementite available for ready graphitisation at the freezing point.

Silicon reduces the stability of the carbide and so promotes graphitisation. In fact, slightly more than 3 per cent. of silicon completely dissociates cementite into iron and graphite. These features will be referred to later, but at the moment it is sufficient to realise that up to about 3 per cent. silicon softens cast iron by reducing the amount of carbide and increasing the amount of graphite.

It also reduces the carbon required to form pearlite, so that an iron containing silicon can be all-pearlitic with less than the 0.9 per cent. of combined carbon mentioned previously for a pure alloy.

Manganese

Manganese combines with sulphur to form manganese sulphide, and in this state has little or no effect upon carbon. The quantity required to combine with the sulphur is 1.72 times the sulphur content plus an excess of about 0.2 to 0.3 per cent. Above this neutralising quantity the Mn forms a carbide intimately associated with the carbide of iron and tends to stabilise it. In quantities above 1 per cent. it gradually reduces the breakdown of the austenite and results in the retention of the transition products, pearlite and martensite, until at above 10 per cent. it will give an austenitic structure.

Manganese therefore tends to prevent graphite formation, although up to 1 per cent. the effect is not very marked. It also reduces slightly the amount of carbon required to form pearlite.

Sulphur

Sulphur when present with insufficient manganese forms an iron sulphide and has a great effect on the stability of cementite, thus reducing graphitisation. The effect is so pronounced that high sulphur in excess of the Mn : S ratio is frequently used to prevent graphitisation in white cast iron and in chilled irons.

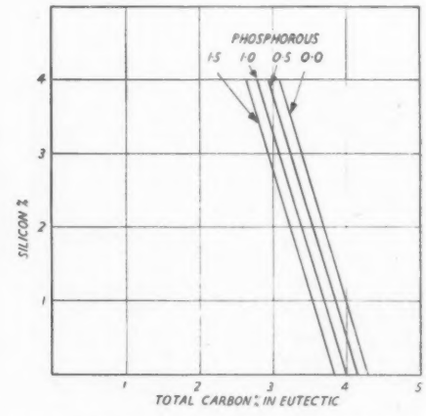


FIG. 9.—EFFECT OF SILICON AND PHOSPHORUS ON CARBON IN EUTECTIC.

Phosphorus

Phosphorus, like silicon, lowers the carbon eutectic by about 0.3 per cent. for every 1 per cent of phosphorus. This is shown in Fig. 9. Apart from this influence explained previously under silicon, phosphorus has apparently no direct effect upon carbon formation. Indirectly it reduces the amount of combined carbon necessary to form an all-pearlitic matrix.

Nickel

Nickel reduces the stability of the carbide and is therefore a graphitiser. Its effect is about one-third that of silicon. In addition it influences the condition of the matrix and in increasing quantities produces harder structures until at around 4 per cent. it produces martensite and if increased further causes the retention of austenite. This effect on the matrix is hardening, whilst the graphitising effect is softening, so that nickel in suitable quantities

FIG. 10.—PHOSPHIDE EUTECTIC. PHOSPHORUS 0.1 PER CENT. × 25.

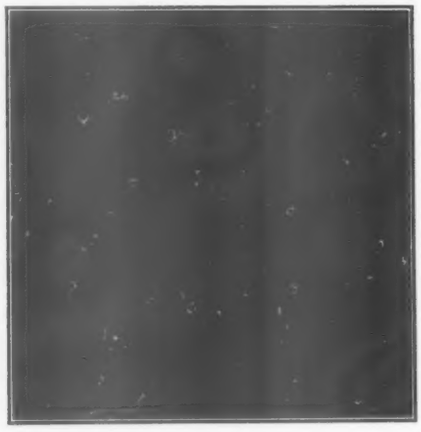


FIG. 11.—PHOSPHIDE EUTECTIC. PHOSPHORUS 0.25 PER CENT. × 25.

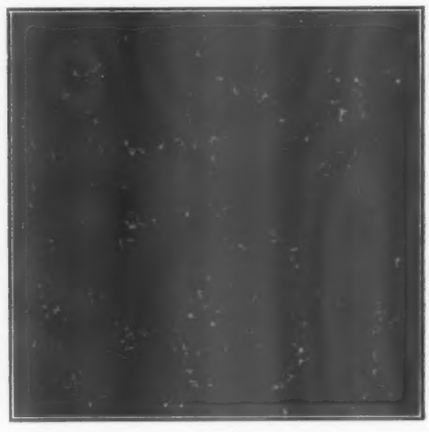


FIG. 12.—PHOSPHIDE EUTECTIC. PHOSPHORUS 0.75 PER CENT. × 25.

softens the chilled and harder sections whilst hardening the softer and grey sections. In larger amounts, say 4 to 5 per cent., it can be used to produce extremely hard cast iron by the formation of martensite.

Chromium

Chromium forms a double carbide with iron which is more stable than the iron carbide. Its effect in stabilising the carbide and therefore hardening cast iron is so great that an otherwise grey soft iron with 3 per cent. of chromium will become fully white with no graphite at all. It is therefore very useful in conjunction with nickel as it neutralises the effect of nickel on graphitisation. Its use in this respect should be in the proportion of one third of the nickel content. Chromium tends to refine the pearlite and make it harder.

EFFECT OF ELEMENTS IN SOLID SOLUTION

It has now been shown how some elements form carbides and are hardeners reducing graphitisation. Elements which favour graphitisation generally do not form carbides, but dissolve in

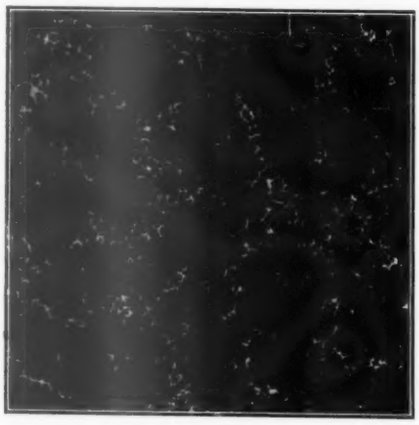


Fig. 13.—Phosphide Eutectic. Phosphorus 1.20 per cent. × 25.

the iron forming a solid solution in the ferrite, in which state they are not microscopically observable.

Silicon

Silicon is one of these, and it hardens the ferrite. This effect is not distinctly noticeable owing to its graphitising action until above 3 per cent. is present, when although causing complete graphitisation the ferrite matrix is extremely hard. This hardness is not valuable as the metal is weak and brittle. High silicon irons have a usefulness, however, which will be explained later.

Copper

Copper is now used to some extent in cast irons. It forms a solid solution, the apparent solubility being up to about 3½ per cent. It has a hardening action on the ferrite, but its chief value lies in other directions.

ELEMENTS FORMING DEFINITE STRUCTURAL COMPONENTS

Some elements form compounds with iron or other elements and exert an effect upon hardness.

Phosphorus

Phosphorus forms phosphide of iron, and is present as a binary eutectic of phosphide and iron in grey cast irons. In white or mottled irons where there is free cementite, the phosphide exists in a ternary eutectic of iron, cementite and phosphide. Discrimination between the two eutectics is not generally made, and they are referred to as the phosphide eutectic or steadite, the name given to the microscopic structure.

One per cent. of phosphorus in iron gives about 10 per cent. of eutectic, which is a hard component, so that the effect of phosphorus as a hardener is quite pronounced. Figs. 10 to 13 show the effect of increasing phosphorus on the amount of phosphide eutectic. Because of the large volume occupied by the eutectic the amount of carbon to form a pearlitic matrix is reduced.

Manganese

This is the only other element to form a compound appreciably affecting hardness, and this does so when present in amounts somewhat equal to the silicon content, say over 1½ per cent. It then appears to form a silicate of manganese which gives hard spots, detracting from machinability.

EFFECT OF THERMAL CONDITIONS

This is a very complex study, and for the purpose in view it is proposed simply to consider the relative cooling rates. It has previously been stated that the carbide, cementite, readily breaks down into ferrite and graphite at high temperatures and less easily as the temperature falls.

Irons above the eutectic carbon composition contain excess cementite which, during solidification, rapidly graphitises because of the very high temperature. Irons of eutectic composition do not free any cementite until they have solidified, when they reject all in excess of the 2 per cent. or thereabouts contained in the austenite. This cementite formed after solidification graphitises less readily than in the case just mentioned. Below the eutectic composition the amount of free cementite on solidification is less still, and further cementite is only freed from the austenite with falling temperature, as previously explained. Graphitisation of this cementite is much slower as it is formed when the temperature is lower. Thus it will be seen that quick cooling reduces the amount of graphitisation and is more pronounced in effect with irons below the eutectic composition than with irons above.

Broadly speaking, then, quick cooling gives less graphite, more carbides and therefore harder metal, and slow cooling produces more graphite, less carbides and softer iron.

The influence of section upon cooling rates is roughly proportional to the ratio of surface area to volume, so that a large section with small area in relation to volume cools slowly; conversely a small section cools quickly. This is well understood. The cooling rate, however, can be much affected by other influences. As the casting cools down so the mould becomes hot, and the nature of the mould material exerts an effect. Sand pockets where there is much surrounding metal will get very hot and slow the cooling of the adjacent metal. This can produce softer iron in a thin section than exists elsewhere in heavier sections. The disposition of gates and feeders has a pronounced effect, and control of cooling rate can often be achieved by movement of gates. The use of chills will enable a hard white fracture to be obtained with a background of soft machinable iron. Figs. 14, 15 and 16 show the structure of chill changing to grey in a chilled cast iron.

HEAT-TREATMENT

The hardness of cast iron is greatly affected by heat-treatment, and this can be carried out either for softening or hardening. In softening or annealing it is necessary to heat the castings to above the pearlitic change point, about 730 deg. C., and cool slowly. The process is essentially one of graphitisation, and any free cementite, such as may exist in chilled edges, can be broken down into graphite and pearlite or ferrite. Grey irons containing no free cementite will be softened by a reduction in the amount of pearlite and an increase in graphite and ferrite.

The longer the annealing time and the higher the temperature the greater is the graphitising and softening effect. In general temperatures around 800 deg. are preferred. The effect is, of course, influenced by chemical composition in a similar manner as described previously.

Hardening is carried out by quenching from above the critical temperature, usually followed by tempering at low temperatures. Cast iron hardens in much the same way as steel except that graphitic carbon is present. When the metal is heated above the pearlite change-point austenite is formed, and this will absorb carbon from graphite or free cementite in quantities according to the temperature and time. Upon quenching the carbon is held in solution. With very drastic quenching it is possible to obtain a high-carbon martensite structure of extreme hardness. Generally the very soft irons do not harden satisfactorily, and alloyed cast irons give the best results. The latter enable slower cooling to be employed while still yielding the hardening constituents. The process, of course, calls for careful operation owing to the danger of cracking the castings.

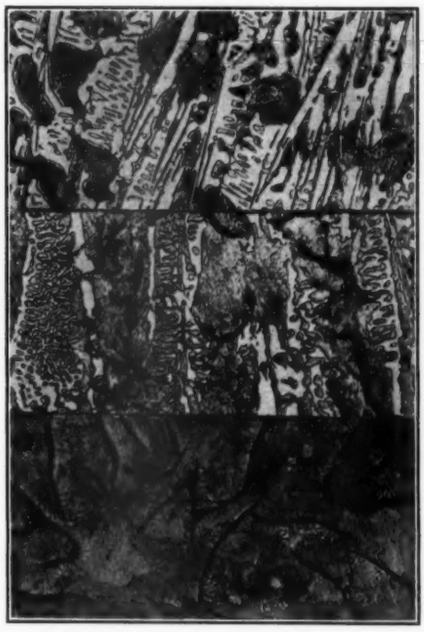


Fig. 14 (top).—White Part of a Chilled Casting. Pearlite and Cementite. × 200.

Fig. 15 (centre).—Mottled Part of a Chilled Casting. Pearlite, Cementite and Graphite. × 200.

Fig. 16 (bottom).—Grey Part of a Chilled Casting. Pearlite and Graphite. × 200.

A further method of heat-treatment is now in use for surface hardening. This is nitriding. The process is carried out by subjecting the metal to an atmosphere of ammonia gas for some hours at a temperature around 500 deg. C. The hardening is the result of the formation of nitrides in the skin, and Brinell hardness values of 800 to 1,000 are obtainable. There is no effect upon the carbon formations. It is necessary to use alloyed irons, and aluminium, chromium, vanadium, nickel, titanium and molybdenum are variously employed.

(To be concluded.)

Melting Point of Silicon

Estimations of the melting point of pure silicon of 99.89 per cent. purity, carried out by F. Hoffmann and A. Schulze by means of thermo-electric measurements and the optical-pyrometer, gave a value of 1,410 deg. C. with an accuracy of ±2 per cent. The melting point of commercial silicon (98 per cent.) was 2 deg. lower according to thermo-electric measurements. A report of this work and a survey of previous estimations are given in a paper in "Metallwirtschaft."

Institute of British Foundrymen

ANNUAL DINNER OF BIRMINGHAM BRANCH

The striking growth of the Branch since its inauguration in 1906 was the keynote of the speeches at the annual dinner and dance of the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen, held at the Edgbaston Botanical Gardens, Birmingham, on January 29. The principal guests were Alderman W. Byng Kenrick (Archibald Kenrick and Sons, Limited, West Bromwich), Mr. C. W. Bigg (President of the Institute) and Mr. R. J. Rogers (Chairman of the Society of British Gas Industries). Mr. H. J. Roe (Branch-President), who presided, had the satisfaction of welcoming a company of members and their ladies numbering upwards of two hundred.

In submitting the toast of the Branch, ALDERMAN BYNG KENRICK recalled that in the seven years since he last accepted their invitation to attend, Birmingham as a city had shown immense growth in prosperity, in the number of persons employed, and in its commercial activities. If the growth of Birmingham in that brief period had been surprising, the growth of the Birmingham Branch of the Institute had been more surprising still. The Institute had had only a comparatively short existence of thirty odd years. Certain far-seeing members of the profession in 1904 perceived that, in a competitive world, the isolation of the foundryman was out of place, and they built wisely and well. He understood that one of the founders of the Institute, Mr. F. J. Cook, was present, and surely he was delighted with the growth of the small association which he and several others started in 1904. They ought not to be unmindful of what they owed to these pioneers in their somewhat difficult undertaking.

As one looked round Birmingham and the Black Country it appeared that the iron foundry and the brass foundry had ever been the principalities of the small man. It seemed as though in the past they had been stronger at dissociation than at alliances; but even foundrymen had to move with the times or move off, and now they had reached the period when a measure of isolated self-sufficiency which was not sufficient was out of date. They had done very well to counter that by their Institute. None of them would be any the poorer if they frankly brought their ideas to the test of discussion and used the meetings for the exchange of ideas.

Continuing, Alderman Kenrick voiced the opinion that foundrymen had never been entirely friendly with the patternmakers, though they counted them as fellow-craftsmen. They had even been a little hostile towards the draughtsmen, and at open war with the designers. If only to protect themselves against their enemies they would do well to combine. Another way of dealing with their enemies was by absorption, and they had adopted that rather more humane process.

Lately they had joined with others in the establishment of a national foundry school. It was interesting to note that it had been established in Birmingham, but it was, of course, for the use of the whole of the Kingdom. This was an extremely interesting development. Only by the support of the larger establishments would it be possible for a constant succession of students to be provided. He knew it was a great deal to ask of these establishments, because they could not possibly absorb all the students they might be asked to provide. On the other hand they could not hope to maintain their position unless there was a reservoir of competent technicians in the industry, and if each, as the opportunity offered, made his contribution to that reservoir, all would in due course be able to draw from it, and the industry as a whole would benefit therefrom. In the promotion of that new enterprise they could not fail to give a word of thanks to Mr. Pearce for the lead he had given. He hoped that, having helped to launch the venture, the industry as a whole, led by the members of the Institute, would enable it to be maintained. He was speaking, he added, as a member of the fourth generation of a family connected with the industry.

The CHAIRMAN, responding, thanked Alderman Byng Kenrick for attending and for his references to the work of the Branch and the Institute. The majority of the members were fully acquainted with the history of the Branch, but he would like to comment on its early days. The first meeting was held at the Birmingham Technical School on April 28, 1906, under the chairmanship of Mr. Robert Buchanan, who was also the first President. It was interesting to know that there was still a link with that pioneer in the person of Mrs. Gameson, the wife of a member of the Council. Its first secretary was Mr. F. J. Cook, who was present with them. At that time the subscription was 3s. per annum, and during the first year the income amounted to £7 15s. Its membership was 51, whereas now it was 315, and the income for 1935 reached the record amount of approximately £450. The results of their organisation were reflected in the many outstanding developments in the industry. Even greater achievements should lay ahead as a result of the courses now in operation at Sheffield University and the Technical College in Birmingham. Their success, however, would depend upon the financial support forthcoming from the industry.

MR. D. H. WOOD, proposing "The Guests," remarked that the company numbered 125. He referred to Alderman Byng Kenrick's services on the Birmingham Education Committee, and observed that last year the number of foundry students passing through the Birmingham Technical School and receiving certificates endorsed by the Institute exceeded that of all the students from all the other foundry schools in the country.

Replying, MR. C. W. BIGG said he was honoured in having to respond for such a distinguished body of visitors. The Institute did not encourage the type of practical man mentioned in a recent broadcast speech—the farmer who was content to perpetuate the errors of his grandfather. It was the Institute's object to introduce new and better methods, which would eliminate the errors of their grandfathers. He heartily congratulated the Branch on the consistently efficient manner in which it continued to contribute to the work and progress of the Institute.

The dinner was followed by an enjoyable programme of dancing, which lasted until shortly before midnight.

Catalogue Received

Steel Forgings. A beautifully-produced brochure on this subject has reached us from the United Steel Companies, Limited, of 17, Westbourne Road, Sheffield, 10. It carries a wealth of illustrations of numerous types of heavy forgings, a field completely beyond the range of foundry competition, except in rare cases. Amongst rare cases is now the possibility of cast marine-engine crankshafts. This book goes to show the meticulous care bestowed upon the production of heavy forgings, and is a lesson to foundrymen on planned production—a lesson they will have to appreciate when engineers decide to make large-scale tests. There is a double-page table centrally positioned in the brochure which very clearly indicates the control imposed and the method of processing. This appeals to us as carrying the lesson for foundrymen to which we made reference earlier.

Speculation in Metals

By "ONLOOKER."

The rally in metal prices on the London Metal Exchange which ushered in the New Year was in no small measure due to a revival of interest by speculators, who, encouraged by the signs of an improving tendency on Wall Street, which in its turn was based on the belief that the Government's rearmament programme would give a fillip to trade generally, made up their minds to abandon their cautious attitude and once again try their luck in commodity futures, although various adverse factors have since brought about a quieter tone. It is a long time since anything like a strong speculative buying movement in metals was evident; since August of last year there has been nothing to give a lead and such speculation as has taken place followed the bear tack rather than the bull.

Everybody remembers what happened in the spring of 1937, when speculators and consumers scrambled for copper in Whittington Avenue and between them lifted values so fast and so far that a serious slump was inevitable. What happened in copper occurred also in the other metals, for the history of lead, tin and spelter followed a course similar to that pursued by the fourth member of the group.

Speculation not Wanted

This incursion by speculators is probably not very welcome to the producers, who have no desire to see the markets getting out of hand again. It certainly is not approved by the consumers, who know only too well the dangers inherent in a situation in which the price of a commodity is being forced up by interests whose sole intention it is to snatch a profit and get clear. It has been said that speculators alone can never hoist a market very far without aid from the genuine trade buyer, and this is probably quite true. At any rate, it is certain that after a speculative rise in values the advance cannot be maintained, unless, at the level attained, industry displays interest and is prepared to take material into consumption at the current price.

These rapid rallies are only too often short-lived, for if the trade refuses the lead given by the speculator then profit-taking ensues, liquidation by tired bulls follows, and on the realisation that the manœuvre has misfired there may even be a measure of bear selling. All this sort of thing is decidedly uncomfortable for the genuine trader, who asks for nothing better than a stable market which exposes him to the minimum of risk on the score of his stock-holding and leaves him in peace to pursue his programme of production and development.

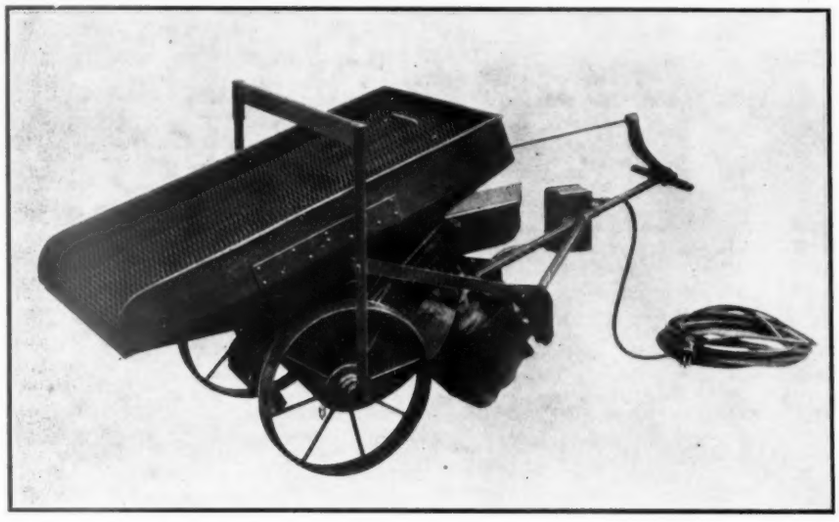
Pointers

Unfortunately, in the metal trade wide fluctuations in prices are more the rule than the exception, for although from time to time the associated producers have been successful in pegging the price for a period, this control has never functioned very long, and the aftermath has usually been such as to make people wish that the idea had never been attempted. It is some consolation for those who have to trade among the ups and downs of the non-ferrous metals that protection may always be sought through the medium of the futures market, and this method of hedging is fairly widely employed.

The return of the speculator to Whittington Avenue is a signal that traders should overhaul their position and arrange a programme of hedging if there is metal which requires protection. In moderation the presence of speculative activity may be quite a good thing, for it does liven matters up and frequently points the way for the consumer and merchant to follow. After all, the financial groups are farseeing, and they do often enough "smell out" a rise in values before the trader has sensed it.

The Screenarator

In the conditioning of foundry sand as knocked out after casting, two processes seem to be essential to obtain the best results—screening and aerating. Most modern sand-handling plants embody units designed for these purposes. For foundries where moderate amounts of sand are being handled and where a large-scale sand-treating plant would be unnecessary and uneconomical, the Screenarator, which is illustrated below, has been designed to carry out these operations mechanically by means of a combined unit of simple and rugged construction, in which the detail components have been carefully planned to withstand the most arduous foundry conditions of handling and service.



The Screenarator Sand Screening and Aerating Unit.

This new machine consists essentially of a hopper with expanded steel-mesh screen discharging into an aerator of the impeller type, both units being driven through helical gearing by a totally-enclosed electric motor. In operation, sand is shovelled on to the screen, which is of corrugated type, to break up lumps and ensure the maximum screening surface. The sand then passes from the hopper into the impeller, from which it is discharged at high velocity through the nozzle situated below the top end of the hopper. The angle of discharge of the nozzle is adjustable, so that the path of the sand through the air may be regulated to suit the conditions. The tailings from the inclined screen are discharged at the lower end.

A substantial knock-out bar is fitted centrally over the screen so that small moulds may be knocked out directly on to the screen, thus obviating shovelling where this procedure can be adopted. To facilitate direct knocking-out, and also to provide easy shovelling on to the screen, the whole apparatus is low set, the lower end of the hopper being only 14 in. from the floor-level. As it is mounted on wheels the Screenarator can be moved into any convenient position on the foundry floor, and is ready to operate by plugging into the nearest electric circuit.

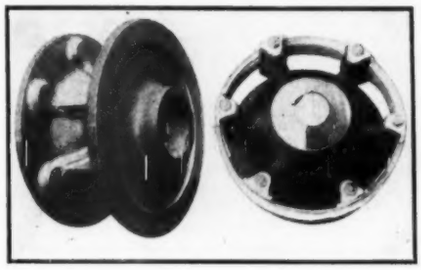
Mechanically, the machine is claimed to be of the most robust construction. It has only one moving part, which revolves on heavy Timken bearings on a stationary shaft. Cut gears are mounted on the impeller. Above the impeller is an eccentric shaft also mounted on Timken bearings, which is attached to the screen, the whole being accurately balanced to ensure freedom from vibration. The movement of the screen, being a combination of gyratory and reciprocating motion, is extremely effective in screening and conveying the sand. All gears and bearings are free from the sand and enclosed in dust-sealed housings. Lubrication is by high-pressure grease-gun. The machine has a high capacity for sand and cannot be overloaded by two men shovelling continuously.

In general, the Screenarator suggests itself for use in jobbing shops where no other sand-preparation equipment is in use, and in production shops where auxiliary sand preparation may be required for floor or bench work. It may be used for conditioning moulding, facing or core sand in iron, steel or non-ferrous work. It is made by Foundry Plant & Machinery, Limited, of 113, West Regent Street, Glasgow, C.2.

American Notes

(From Our American Correspondent.)

Approximately 75 per cent. of the millions of heavy-duty lorry and lorry trailer wheels on the highways of the United States to-day are malleable iron castings. Behind this fact lies the story of the rapid development of the lorry wheel industry, and the progress from the cumbersome, heavy solid-tyre wheels of earlier days to the modern, lightweight wheel. Foundry engineers have contributed much to the progress and improvement of wheel manufacture.



Dual Lorry-Wheel Hub (left) and Finished Lorry Wheel with Rim and Brake-drum attached (right), both in Malleable Cast Iron.

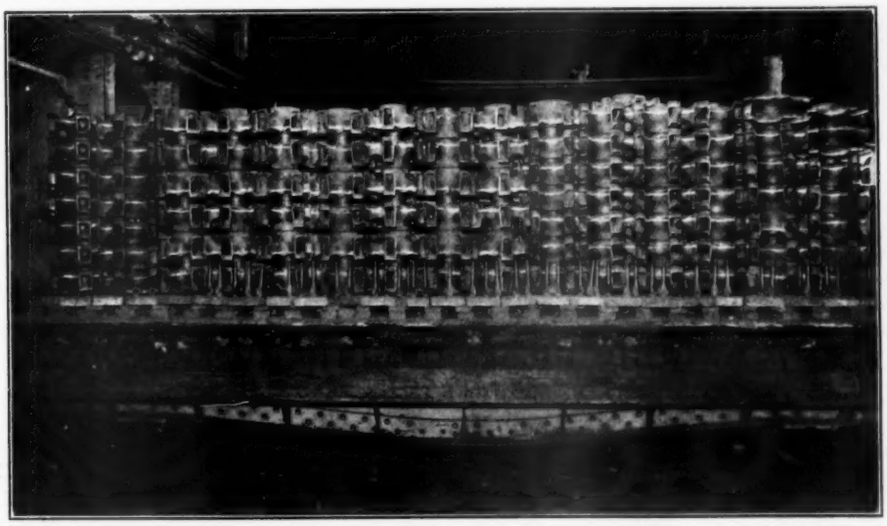
The mechanical and physical properties of malleable iron, and the manufacturing methods involved, provided the opportunities for producing a wheel which would be light in weight, extremely tough and shock-resistant, and economical. From the manufacturing viewpoint, malleable iron permitted rapid quantity production, and possessed the ability to cast smooth, thin objects true to pattern without sacrifice of strength; coupled with this was a superior machinability necessary for the high-speed close-tolerance machining operations. These factors rendered substantial weight savings possible. The light fin on the casting assures a superior parting line to the wheel.

The first malleable iron wheels were cast as single units, but the size and design required for the solid-tyre type then in use led to several

(*Concluded from next column.*)

were redesigned to accommodate demountable rims.

Five years later the demand for dual pneumatic tyres on heavy-duty lorries led to further changes. Brake-drums became larger, and wheel and tyre sizes smaller, so that the wheel foundries were faced with the problem of casting intricate thin-walled designs without sacrificing the reputation for strength and neat appearance their product had attained. This involved improvement in all production equipment. The highest-grade pattern and moulding facilities were adopted, and improvements in annealing equipment permitting shorter cycles and more rapid delivery periods also followed.



An Annealing Car in an American Foundry loaded with Malleable-Iron Lorry Wheels for Heat-treatment.

production difficulties. As a result, wheels came to be cast in four sections, which were then riveted together. This step resulted in a cheaper product, and this type of wheel was used successfully until the transition in 1920 to pneumatic tyres. As a result, wheels became smaller and

(*Concluded in previous column.*)

Time and Motion Study in the Foundry

By C. D. POLLARD

(*Continued from page* 120.)

Underlying Principles

There are no printed rules and regulations posted about the works concerning the working of the scheme; the necessity for this course to be adopted has never occurred, as both sides work to the spirit of the arrangement with apparent satisfaction.

There is one unwritten law, however, which is strictly adhered to and observed to the letter. It is that, once a piecework price is fixed, it must remain unaltered, unless the pattern plant is modified, or an alternative method of production is adopted.

Naturally, there are times when changes in the method of running or feeding, or other alterations, are considered advisable after a pattern has gone into production, and in such cases the foundry manager discusses the matter with the time and motion study department, who prepare a new estimate covering the suggested alteration to procedure. Providing the modification does not increase the cost of production; all is well, and the people concerned are notified of the change; if the modification increases production cost, however, the foundry manager must decide whether the contemplated improvement of the castings, or saving in rejects, is sufficient to justify the suggested modification to procedure.

If he considers it policy to make the alteration despite the added cost, the necessary retiming of the job is carried out by the investigators from the time and motion study department, the piecework prices are adjusted, and all record cards are amended to the new figures.

The stage has now been reached where a job is in production, satisfactory prices have been fixed, and the investigators have checked every operation, second for second against estimate, to prove that actual labour cost does not exceed the estimated cost on each separate operation. If it should happen that there is a discrepancy in any one operation, the costs department, with all the facts laid before them by the time and motion study department, prepare a cost per unit, and the foundry manager is advised as to what extent the production cost is affected. At the same time it is the duty of the investigator, and in the interests of the foundry manager, to investigate the circumstances and reorganise the labour and the use of materials if at all practicable, to bring the cost within estimate figures. The positive nature of the figures presented by the investigator leaves no doubt as to whether production costs are on the right side or not, and also leaves no doubt that the overheads on any particular unit will be absorbed, provided the standard output is maintained.

These are, in the author's opinion, the most important phases of the system, because it is at this stage that one wants to know how actual costs and estimates compare.

To make any attempt in the space available to show reproductions of each type of reference or index cards in use by the time and motion study department would be impossible. But it is desirable to give sufficient evidence to justify the statement that the investigators give positive figures when estimating or setting standard times for various operations in the foundry.

COPY.

DERWENT FOUNDRY CO., LTD., DERBY. STANDARD TIME CARD. 15.

Description of Job:- Machine No 8. Flask 16x10x8=5

Replace Presser board on shelf. Cut 1 sprue with cutter, + rap plate with light wooden mallet.

Note:- This is same for all flasks

STANDARD 9.3 secs. BASED on 4/+/1-27

Drawn up C.G. Date 1/3/16 Checked GJ Date 1/3/16

Approved GJ Date 1/3/16

DERWENT FOUNDRY CO., LTD., DERBY. STANDARD TIME CARD. 17

Description of Job Machine Moulding. Farwell Squeezer.

Flask 17"x11"x5+4"

Close mould, unwrap flask, and rewrap flask on table.

STANDARD 17·6 secs. BASED on 72/+/1-27

Drawn up Rab. Date 12/6/19 Checked GJ Date 12/6/19

Approved GJ Date 12/6/19

DERWENT FOUNDRY CO., LTD., DERBY. STANDARD TIME CARD. 137.

Description of Job Moulding (Machine)

Shovel in one shovelful of sand.

(Does Not include picking up and replacing shovel.)

STANDARD 2·5 secs. BASED on 251/+/1-13 and 212/+/1-52

Drawn up Rab. Date 21-10-19. Checked Date.

Approved GJ Date. 11/11/19

DERWENT FOUNDRY CO., LTD., DERBY. STANDARD TIME CARD. 139.

Description of Job Moulding. (Machine)

Shovel in One shovelful of sand.

(includes picking up and replacing shovel)

STANDARD. 6·6 secs. BASED on 218/+/1-68 251/+/1-13

Drawn up. Rab. Date. 6-10-19. Checked Date.

Approved GJ Date 7/10/19.

FIG. 9.—STANDARD TIME CARDS PREPARED IN 1916 AND 1919.

1916 and 1919 Reference Cards

Fig. 9 is a reproduction of four standard reference cards which have been in constant use since the respective dates shown upon them; they are representative of thousands of such reference cards in the files, which comprise that centralised and permanently-recorded knowledge to which reference was made earlier. Taking the oldest card reproduced on Fig. 9, it is shown that this standard was established in 1916, and it is referred to to-day as the recognised and accepted standard for that particular operation.

Looking at the two lower cards, Nos. 137 and 139, is it possible to estimate the quantity of sand that has been handled in this foundry, or the number of operators who have lifted shovels for the purpose of shovelling that sand, during the period which has elapsed since October, 1919? Obviously it is not, but it should be realised that all the wages for doing that work have been paid at the rate of 6.6 seconds for one shovelful, and 2.5 seconds for each remaining shovelful required to fill each mould that has been made.

Sand Shovelling Times

It can also be taken for granted that a number of operators have doubted these standards, and have been re-timed at their own request, but the standards set up in 1919 still stand as satisfactory to all concerned. For instance, in Fig. 10 is a reproduction of a card taken from the files at random, showing the standard for filling a moulding box with 16 shovelfuls of sand, on a job which was timed in 1936. It shows a total time of 44.1 seconds. This standard was made up from the cards 137 and 139 shown in Fig. 9; thus one shovelful at 6.6 seconds and 15 at 2.5 seconds each give a total of 44.1 seconds for the 16 shovelfuls. This example is typical of thousands of others which are governing the estimating and production costs every day.

Attention has principally been directed to the working of the scheme in the moulding shops, simply because there is not sufficient time to cover all the sections of the foundry, and moulding is the most important process. The estimating and control of costs for coremaking, knocking-out the castings, grinding and fettling, and the preparation of backing sand, are carried out by investigators on exactly the same principles, and remarks regarding procedure in time and motion study of moulding operations would apply to the other processes. Figs. 11 to 13 will serve to illustrate this point without going into too much detail.

Job Cards

Fig. 11 shows specimen job cards for the easy reference to piecework prices and standards for any particular process on any particular pattern.

QUALCAST LIMITED 8963

Operation Moulding (Machine)

Fill 16 shovelfuls of sand in Cope (or drag)

Standard 44·1 Secs. Based on Cards 137 and 139.

Drawn up by A. 2.7.36 Checked by Approved by A. 2.7.36

FIG. 10.—STANDARD TIME CARD FOR OPERATION OF FILLING MOULDING BOX.

The job number as such on these cards is actually the reference number of the instruction cards which would be made out and issued to the works when the job was in work. Taking these cards in rotation, No. 12909 is the reference card to the moulding of the job, and 12910 the pouring of the moulds, which in this case would be done from hand ladles and not direct from the crane ladle. Nos. 12911 and 12912 cover the knocking-out of the moulds, taking the castings and scrap from the casting floor, and mixing the backing sand ready for use the next day.

Where more than one type of core is required per casting, corresponding reference cards (Fig. 12) are made out and filed. In this case four different types are used and the information regarding their production is fairly well covered by these cards. They show that seven cores in all are required for each casting off Pattern No. 5396B, what sand mixture is to be used, how many driers are required, the piecework prices, standards, etc.

An incidental benefit the planning department may derive from the information on these cards is indicated by reference to Card No. 12909 (Fig. 11) which showed that 35.4 castings was the daily standard output, and on the coremaking cards it is shown that the standard production of the body cores for this job is 213.6 per day,

so that one day's work on these cores will give sufficient body cores for 6 days' moulding output, but one day on centre cores will not be quite sufficient for 2 days' moulding, and so on. These and other index reference cards obviously simplify the planning of the work.

Specimen Cards for Dressing

Typical job cards are shown in Fig. 13. It will be noticed that on these, as well as on those illustrating the coremaking and moulding, is the pattern number 5396B, whilst Fig. 14 shows the master index card. Should it be necessary to re-estimate for, or seek reference to, the manufacture of castings from Pattern No. 5396B, a glance at this card shows the avenue to the cards on which the necessary information will be found.

One of the incidentals to the scheme which is worthy of mention, on account of its importance in its effect on production, is the experimental work carried out on all new jobs prior to the pattern plant being issued to the foundry. This experimental section is controlled by the foreman patternmaker, who supervises the making of trial moulds and cores, the closing of such moulds, etc., in order to eliminate such variables as core filing, bad lifts, mismatch, etc. The moulders in this section, by the way, are skilled men.

When the trial casts are made, the resultant castings are taken to marking-off tables in the patternshop, and when the samples are not correct to drawing, or are flashed, or otherwise unsatisfactory, the pattern plant is rectified or touched up where necessary. Such trials and re-trials are carried out at the discretion of the foreman patternmaker, and he does not issue the plant to the foundry until he knows it is satisfactory in all respects.

It will be appreciated that this procedure is a necessity, because the object of machine moulding, apart from speed and cheapness, is to get perfect moulds on the floor, if such are at all practicable. Much money is spent on pattern plant in order to make this possible, and any necessity for tooling on the moulds, or core filing, or rubbing, is considered bad practice. In fact, the time study investigators have no authority for allowing time on such operations.

Conclusion

An endeavour has been made to explain the system of control in as brief a manner as possible, without introducing too many figures. The author has tried to convey the correct atmosphere created in the foundry and to afford readers the opportunity of forming some idea, if only vaguely, of what it means to workpeople and staff where such a system is employed. There are many ramifications either directly or indirectly connected with the system, many of which would form the basis of long discussion, and it would be far too big a task to attempt to cover all the important features surrounding the application of the scheme. Therefore, quite a number of incidentals to the system have not been mentioned, but by this omission it must not be deduced that they are unimportant. To do justice to the costing system, for instance, one would resort to innumerable figures, to such an extent that no time would be left for attention to other phases. An explanation of the internal working of the index systems and interchange routine between the time and motion study and costs departments has been left out for the same reason.

To a certain extent it was not intended that such features should come within the scope of this Paper, for as was indicated initially, the object was to give some idea of how the production of castings was affected by the application of time and motion study methods of control.

One hears at times that such schemes as the one under consideration remove the encouragement of, and the necessity for, scientific training, initiative and personality in the foundry.

(*Concluded on page* 144.)

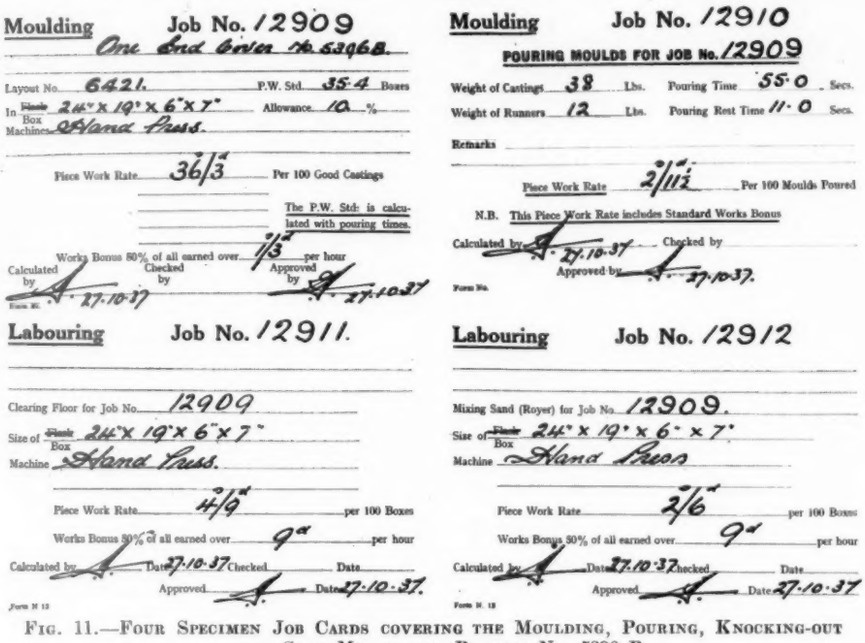

Moulding Job No. 12909
One End Cover No. 5396B.
Layout No. 6421. P.W. Std. 35·4 Boxes
In Box 24" x 19" x 6" x 7" Allowance 10 %
Machines Hand Press.
Piece Work Rate 36/3 Per 100 Good Castings
The P.W. Std. is calculated with pouring times.
Works Bonus 80% of all earned over 1/3 per hour
Calculated by 27.10.37 Checked by Approved by 27.10.37
Moulding Job No. 12910
POURING MOULDS FOR JOB No. 12909
Weight of Castings 38 Lbs. Pouring Time 55·0 Secs.
Weight of Runners 12 Lbs. Pouring Rest Time 11·0 Secs.
Remarks
Piece Work Rate 2/11½ Per 100 Moulds Poured
N.B. This Piece Work Rate includes Standard Works Bonus
Calculated by 27.10.37 Checked by
Approved by 27.10.37.
Labouring Job No. 12911.
Clearing Floor for Job No. 12909
Size of Box 24" x 19" x 6" x 7"
Machine Hand Press.
Piece Work Rate 4/9 per 100 Boxes
Works Bonus 80% of all earned over 9d per hour
Calculated by Date 27.10.37 Checked Date
Approved Date 27.10.37.
Labouring Job No. 12912
Mixing Sand (Royer) for Job No. 12909.
Size of Box 24" x 19" x 6" x 7"
Machine Hand Press
Piece Work Rate 2/6 per 100 Boxes
Works Bonus 80% of all earned over 9d per hour
Calculated by Date 27.10.37 Checked Date
Approved Date 27.10.37

FIG. 11.—FOUR SPECIMEN JOB CARDS COVERING THE MOULDING, POURING, KNOCKING-OUT AND SAND MIXING FOR PATTERN NO. 5396 B.

Core-Making Job No. 25601.
Casting Blank's End Cover 5396B.
Description of Core Body Core.
Plant Iron core-box. (One core per casting)
Sand Mixture No. 2.
Standard Time 125·60 Secs.
Daily Piece Work Standard 218·6 Cores
Piece Work Rate 2/3 Per 100 Good Cores
Works Bonus. 50% of all earned over 5d per hour
Calculated by 26.10.37 Checked by
Approved by 26.10.37.
Core-Making Job No. 25602.
Casting Blank's End Cover 5396B.
Description of Core Stamber Core.
Plant Iron core-box & 20 drims
Sand Mixture No. 2B. (2 cores per casting)
Standard Time 94·05 Secs.
Daily Piece Work Standard 292·6 Cores
Piece Work Rate 1/8 Per 100 Good Cores
Works Bonus. 50% of all earned over 5d per hour
Calculated by 26.10.37 Checked by
Approved by 26.10.37.
Core-Making Job No. 25603.
Casting Blank's End Cover 5396B
Description of Core Centre Core.
Plant Iron Core-box (one core per casting)
Sand Mixture No. 2.
Standard Time 41·0 Secs.
Daily Piece Work Standard 67·2 Cores
Piece Work Rate 9d Per 100 Good Cores
Works Bonus. 50% of all earned over 5d per hour
Calculated by 26.10.37 Checked by
Approved by 26.10.37.
Core-Making Job No. 25604
Casting Blank's End Cover 5396B.
Description of Core Ram-up.
Plant Iron core-box & make 3 cores (3 cores per casting)
Sand Mixture No. 2.
Standard Time 50.00 Secs. for 3 cores.
Daily Piece Work Standard 1653. Cores
Piece Work Rate 4d Per 100 Good Cores
Works Bonus. 50% of all earned over 5d per hour
Calculated by 26.10.37. Checked by
Approved by 26.10.37

FIG. 12.—FOUR REFERENCE CARDS RELATING TO THE CORES REQUIRED FOR THE CASTING FROM PATTERN NO. 5396 B.

Dressing Job No. G.1089
Grinding one Blank's End Cover No. 5396B.
Standard Time 402·3 Secs. Remarks
Daily P.W. Standard 68·5
Grade 1. Operator
Piece Work Rate 13/9 Per 100 Good Castings
Works Bonus 50% of all earned over 10d Per Hour.
Calculated by 28.10.37. Checked by
Approved by 28.10.37.
Dressing Job No. F.1090
Chipping & Filing one Blank's End Cover No. 5396B
Standard Time 245·0 Secs. Remarks
Daily P.W. Standard 112·42
Grade 1. Operator
Piece Work Rate 8/5 Per 100 Good Castings
Works Bonus 50% of all earned over 10d. Per Hour.
Calculated by 28.10.37 Checked by
Approved by 28.10.37.

FIG. 13.—CARDS FOR DRESSING OPERATIONS ON CASTINGS FROM PATTERN NO. 5396 B.

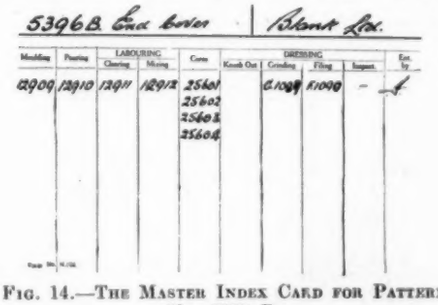


FIG. 14.—THE MASTER INDEX CARD FOR PATTERN NO. 5396 B.

The New Laboratories of Crane, Limited

A COMMENDABLE ENTERPRISE AT IPSWICH

By VINCENT C. FAULKNER

The ideal research laboratory, according to Brearley, consists of an empty room. There is wisdom in this aphorism, but those cognisant with this phase of activity realise that the room must be of a suitable character, and that it must possess auxiliary services. What Mr. Brearley implied is that a block of excellently-equipped laboratories is neither necessary nor invariably conducive to the production of new knowledge. The writer remembers visiting a Continental University which was both thoroughly and expensively equipped with every type of testing apparatus available to the scientist, yet he received the impression that it was a morgue.

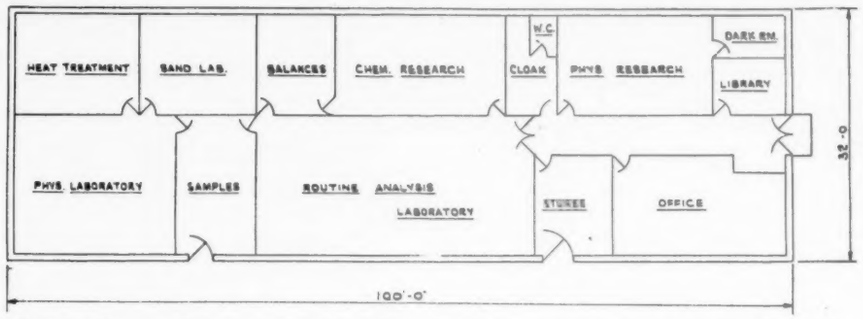


FIG. 1.—GENERAL LAY-OUT OF THE NEW RESEARCH LABORATORY OF CRANE, LIMITED, IPSWICH.

For a research department to be a worth-while institution, it must be animated by well-defined aims and objects, in exactly the same way as a limited company or a friendly society, and these aims were clearly enunciated by Crane, Limited, of Nacton Works, Ipswich, before the creation of their new research laboratories and their equipping. In this case, the underlying principle animating the research department is a well-conceived effort to eliminate, as far as possible, all "hit and miss" or "rule of thumb" methods, which are always likely to find some place in industry. The standardisation of processes by scientific control very materially lessens any chance of error.

Such efforts obviously concern every possible activity, from buying. through manufacturing to selling, and ample provision has to be made for the company's very differing requirements. Primarily, the department acts as a liaison with external co-operative bodies—in this case the appropriate co-operative research associations and the Institute of British Foundrymen. It specifies the properties of the raw materials and ascertains that deliveries comply with these specifications. It imposes technical control on all manufacturing processes, records the results obtained, originates better methods, and investigates deviations from standard practice, whether this results in higher production or increased scrap. Finally, the reduction of waste is ever under consideration.

To achieve such a programme it was decided to create an entirely new building, separated from the manufacturing shops, which would house the following departments:—Office, library, stores reception, routine chemical analysis, samples reception and preparation, physical and mechanical testing room, thermal treatment, balance room, chemical research and general utility room, physical research room and lecture theatre and dark room.

The general layout of the laboratories and the external appearance are shown in Figs. 1 and 2. Immediately on entering is a small study, to which the staff may retire to make themselves familiar with the existing knowledge on any subject they have under consideration. Most of the staff of the department spend the major part of their time in the actual works, being responsible for the control of some manufacturing phase. They resort to the laboratory to conduct small-scale work, which, when showing promising results, is the subject of a research of major character, in which case a proper job number is taken out and a monetary allocation made. A typical case was the ascertainment of the minimum quantity of core oil essential for the production of a certain core. The establishment of this figure was considered worthy of extended investigations on the subject of the ascertainment of the minimum requirements of core oils for cores in general.

On the left of the central corridor is the chief metallurgist's office, wherein not only is general direction effected, but the results are charted for easy interpretation by the administration, manufacturing and sales staff. On the opposite side of the corridor, next to the study, is the physical laboratory, the principal piece of equipment in which is a Leitz Panphot microscope. This is so arranged that it can throw images on to a screen on the wall, or on to a drawing board which, when not in use, slides beneath the bench top. Alternatively, the image can be seen upon a ground glass surface, or projected on to a sensitised plate for photographing. Accessories for examination by polarised light are also included. It can deal equally well with metals, minerals, or even biological specimens, and warrants as much as any instrument can warrant the term universal. The windows have been specially designed to carry light-proof blinds, and by means of hinged laths, the blind is pressed tightly to the window. Polishing apparatus and a few other microscopes complete the equipment of this laboratory, and plenty of bench room is available should additional equipment be found necessary. Leading out of this room is the dark room.

A small room next to the office is the stores-receiving department, having a door leading to the open air. Only stores which have to be paid for enter this room, and they comprise in the main chemicals and glassware. For the reception of materials to be tested, a separate room is provided, which contains the essential reduction machines, such as a drill, crushers and the like. No material is accepted without an order form, and officials likely to require the services of the laboratory have received a interdepartmental circular, which informed them of the size and nature of samples suitable for handling by the laboratory. Actually, much waste can be involved, as, for instance, by sending in a couple of feet of an inch-square bar of high-speed steel for chemical analysis, when a couple of inches is

FIG. 2.—EXTERIOR ASPECT OF THE NEW LABORATORIES.

FIG. 3.—PHYSICAL RESEARCH DEPARTMENT, SHOWING THE LEITZ PANPHOT MICROSCOPE AT THE LEFT.

more than ample. It is incumbent on the laboratory to set an example in the reduction of waste.

The corridor, previously mentioned, leads to a well-lighted (21 foot-candles average) routine chemical laboratory. Much of the equipment was salved from the earlier laboratory and renovation has made it difficult to believe that some fixtures are seven years old. Amongst equipment which has been introduced since the writer had laboratories under his control are the Strohlein carbon tester, which Mr. Shepherd, the chief metallurgist, states to be exceptionally reliable and reasonably quick in operation; burette fixtures, involving the use of a ground-glass plate, carried in a frame and placed in front of the windows; the use of much asbestos composition piping for ventilating the stink cupboards; bunsen burners of ceramic ware—parenthetically, there seems to be an outlet for vitreous-enamelled ware for this application—and finally dinner wagons for transporting desiccators, beakers and the like to and from the balance room. The lay-out of the laboratory is such that, apart from the fact that there is ample space permitting of the segregation of non-ferrous and ferrous determinations, there is the further possibility of separating estimations which are chemically detrimental to each other. A typical case would be the estimation of chromium, involving the use of sulphuric acid, and the determination of sulphur in an alloy.

Beyond the chemical laboratory is the test house, and here one is immediately attracted to the smart appearance of the various machines, as, wherever possible, all the parts have been chromium plated. Included in the equipment are an Avery universal testing machine; torsion and Brinell apparatus.

An interesting laboratory is designated the chemical research laboratory. Actually, at the moment it is used for empirical tests, and typical of this work at the time of inspection was a number of experiments in progress involving the blowing of steam on to galvanised and aluminium-coated malleable castings for fixed periods. Obviously, for a works possessing a large malleable cast-iron foundry, heat-treatment is of special interest, and the laboratory devoted to this phase is particularly well equipped with precision temperature-controlled electric and gas-fired muffle furnaces. Here the complete thermal procedure can be planned in advance for any composition of iron, with an assurance that the conditions can be duplicated in the works.

The research work on sands emanating from this organisation has already received the wide approbation of foundry technologists, and the laboratory devoted to both routine and investigational work is adequately equipped, utilising, in the main, American Foundrymen's Association standard apparatus. This has been chosen, not only because the Americans were pioneers in this field, but also because the Crane concern is connected with manufacturing establishments in other parts of the world and by utilising the same set of instruments the various staffs all "speak the same language." Thus elutriation tests are not practised, and confidence is placed in dry sieving, associated with the permeability, shear, crushing and other standardised tests.

How the Laboratory Functions

Amongst the services rendered to the buying department by the laboratory is the issuing of specification sheets for purchased materials. To this end, a very intelligent general form has been prepared. After giving the sheet a number and date, there is a line for indicating to what the specifications refer. The next entry is extremely useful and reads "Purposes for which this material can be used." The balance of this page merely contains the significant term "Notes." Overleaf, entries are made under the following headings:—Chemical Composition; Physical Properties; Information to be included on Purchase Orders; Approved Sources of Supply; Compiled by, and finally places for signature by the appropriate officers of the company.

For the control of each process, a special form is issued. This form puts on record the following information:—Date Issued; Process or Formula Number; Department; Formula or Process relating to.....; Class of Work to which Applicable; and Details of Formula or Process. This last entry not only provides a dozen lines upon which to type or write, but each line is furnished with an £ s. d. extension labelled "Cost of Material." Additionally, the word "Details" carries an asterisk calling attention to a footnote, which reads: "If revision—

Fig. 4.—General View of the Chemical Laboratory.

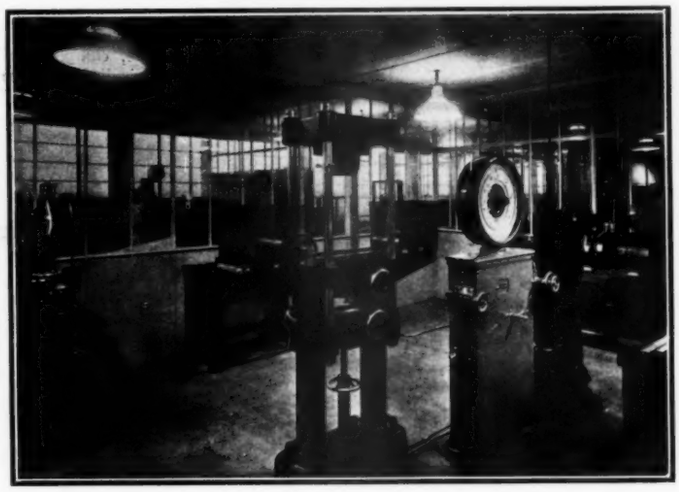


Fig. 5.—Mechanical Testing Room.

Fig. 6.—Heat-treatment Laboratory. Note the Excellent Lighting.

Fig. 7.—Sand Testing Laboratory.

Reason." There are, of course, the usual authorisation and approval signature spaces. A suggestion in this connection is that there should be two extra entries reading "Cancels No....." and "Replaced by No....." This would effectually prevent the wrong specification accidentally being utilised, and, moreover, would help when process modifications were being envisaged.

For the sales department, the laboratory is able, by means of cinematograph films and the projection of microsections on to the screen, to help the commercial representative to appreciate the fundamental properties of the materials used, and the work which is put into them in order to ensure a satisfactory and reliable product. A salesman so informed not only becomes more enthusiastic as to his company's products, but will refrain from giving ill-considered technical opinion by invariably referring all such matters to an obviously competent authority.

Works Developments

After concluding the visit to the laboratories, a hasty tour of inspection was made of sections of the works where extensions had been made, and the following are disconnected notes dealing with recently-introduced phases of activity.

Since the writer's last visit, an entirely new department has been created for the manufacture of central-heating boilers. The largest castings for these are made on large jolt-roll-over machines and are surfaced on 6-ft. diameter horizontal grinders. A rotary table type of Wheelabrator—the largest he has so far seen—is used for cleaning the surface of these castings. A new battery of ovens has been installed by Controlled Heat & Air, Limited, for core drying. It involves the very sound principle of re-circulating the combustion gases and air to ensure uniformity of heat distribution and complete removal of moisture from the cores before the second stage of the process—the actual baking—takes place.

Another new feature noted in the control room was the automatic recording of production. Every time a moulding machine table is operated, it depresses a spring which contacts with an electric circuit connected with a counting and totalling machine. This machine also automatically records every cupola tap, and by its means, regular tapping and uniformity of metal composition are aided considerably.

The collection and handling of slag is another problem for which the management has found a simple solution. A stout, open-ended conical cast-iron "ingot" mould, made in two halves and furnished with heavy trunnions, rests on a small wagon running on a light railway, connecting the cupola slag notches and the sidings. The slag "ingot" is easily removed by inverting the mould, and being of a friable character breaks readily on discharging; in doing so, it reveals the presence of any iron. This iron exists in the form of a ring and is reclaimed without difficulty.

A final development is the installation of a continuous galvanising plant, claimed to be of unique character. Malleable castings, after pickling, washing, neutralising and re-washing, are attached to a Bagshawe chain conveyor, which carries them through the ammonium-chloride flux and then processes them through a 16-ft. long galvanising bath.

Conclusions

The writer regrets that, through no fault of the management, time did not permit of a more intensive study of some of these newer developments, each one of which is certainly worthy of a special article.

He sincerely congratulates the direction of the Crane Company on the commendable enterprise it has shown at the Nacton Works, and tenders his very hearty thanks to Mr. G. C. Detlefsen, the general superintendent, and Mr. H. H. Shepherd, the chief metallurgist, for the many courtesies extended, and for the considerable help given in the preparation of this article.

High-Speed Snagging Equipment

We illustrate a Norton 24-in. swing frame machine as supplied by Alfred Herbert, Limited, of Coventry. For snagging miscellaneous castings, and for grinding ingots and billets, if the best results are to be obtained, it is essential that the operator shall be able to see exactly what the grinding wheel is doing. The machine, complete with its motor and grinding wheel, is light for its duty, being no more than 900 lbs. It is also flexible, and being balanced both laterally and rotatively is very easy to handle.

The absence of outboard bearings affords the operator maximum visibility, whilst the wheel head is only 8 in. wide overall. Double-barrel (railroad-type) ball-bearings are used in the wheel head, the complete bearing assembly is within the hole in the wheel and is absolutely dustproof. The drive is transmitted from the motor to the wheel head by V-belts, which are particularly suitable for the duty as chips and dirt, removed in grinding, slide off whereas with a flat belt they would ultimately become impregnated in the belt surface. A duplex quick-changeable sheave on the motor makes two speeds possible. Either 24 in. or 20 in. dia. wheels can be operated at a peripheral speed of 9,500 ft. per min.

The motor elevating screw allows for sensitive adjustment of the belt tension. It also furnishes a quick and effective method of releasing the motor to slack off the belts when changing wheels, or when stepping up the speed after the wheel has been worn to 20 in. dia.

The machine may be suspended in two ways, *i.e*, single suspension at the centre, a method which is very convenient when the head-room is restricted, or by double suspension, at both the wheel head and the motor. In this method the motor end is rigidly held from the roof by a rope or cradle, while the wheel head is supported by a counter-weighted rope running over pulleys.

HIGH-SPEED SNAGGING MACHINE IN OPERATION.

There are times during grinding angular surfaces when it is desirable to tilt a swing frame and lock it in position. For this purpose a locking device controlled from the operating position has been provided, and rotation of 90° clockwise and 80° anti-clockwise is possible.

The overall length of the machine is 134½ in., the overall width at the motor end being 30 in.

Time and Motion Study in the Foundry

(*Concluded from page* 141.)

Such views are untenable. The production of castings in any metal from moulds made on machines, or by other repetition methods, calls for much common sense and organising ability on the part of the executive staff in the foundry, but the basis of that production must be sound and scientific knowledge of the subject, as a result of technical training and practical experience.

The evolution in the foundry trade which has led, through keen competition from abroad and in other directions, to the necessity for so much machine-moulded production, has resulted in limited opportunities for training the majority of the boys who enter the foundries to become skilled craftsmen.

The only personal observation called for is that if one analysed the opportunities for training boys in two foundries where the whole of the production was from moulding machines, one foundry being controlled by time and motion study and the other not so controlled, one would not find the latter offering better facilities for training the boys than the former. This is a very controversial subject and does not come within the scope of the Paper, and it is hoped that no one will try to draw the author into a discussion on this matter, nor on the merits of machine moulding by unskilled or semi-skilled operators and boys as against the work being done by skilled labour. Machine moulding and mechanisation of foundries have come to stay, regardless of the system of control the foundries may adopt.

In conclusion, the author wishes to express his sincere thanks to Mr. V. Jobson, managing director, and Mr. C. W. Bigg, assistant managing director, of Qualcast, Limited, for permission to read this Paper, and to express his appreciation to those of his colleagues who assisted in the preparation of the Paper and the necessary slides.

Marine Engineering Merger

A scheme is announced for the reorganisation of the capital of Richardsons, Westgarth & Company, Limited, marine engineers, etc., of West Hartlepool, and for the amalgamation of the company with two other North-East coast concerns—the North Eastern Marine Engineering Company, Limited, and George Clark (1936), Limited. Meetings to consider the proposals are called for February 21.

Production and Properties of Steel Castings*

By F. COUSANS

Present-day trends in engineering practice appear to be in the direction of lighter structures and parts, and at the same time the components may be called upon to carry heavier working stresses. An examination of the finished products now being made by some of the important modern steel foundries tends to confirm these tendencies, for it will be observed that the castings now being made are generally of lighter sections and are produced either from alloy steels or from carbon steels, and are scientifically heat-treated. This is a remarkable tribute to a very happy combination, the scientific worker and the skilled craftsman.

There is such a wide variation in the designs now produced, and in the nature of the steels used, that it is very difficult to describe adequately the production methods employed. It is considered that a statement of what are the generally accepted guiding principles in the manufacture of steel castings may be of interest, and the following notes are offered with the hope that they will give an indication of the large amount of scientific research which has taken, and still is taking, place in steel foundries and of the large amount of care and precise control which are needed if the finished products are to be reliable and regular.

MOULDING SANDS

The moulding sands used in the production of steel castings in this country, until recently, were of the naturally-bonded type. This was probably due to the fact that there are available considerable quantities of sands which could be regarded as fairly suitable for jobbing work. The application of machine-moulding methods has resulted, however, in the development of synthetic and artificially-bonded sands. The question of refractoriness is the most important consideration in the selection of any sand for use as a facing in moulds used for producing steel castings. The temperature which the mould facing may be called upon to resist may be close to 1,650 deg. C. in the case of very light-section carbon-steel castings, whilst for the heavier-sectioned ones it will probably be close to 1,540 deg. C.

Alloy additions to steel have a remarkable effect upon the fluidity of steels and upon their ability to run thin sections. Nickel-chrome steels at a temperature of 1,550 deg. C. are fairly sluggish, whereas manganese steel containing approximately 13 per cent. manganese is very fluid at the much lower temperature of 1,450 deg. C., so that in the case of the former it is necessary to use a higher casting temperature, and the moulding sands used must possess higher refractoriness. It will be appreciated, therefore, that in a steel foundry producing castings from a wide range of alloy steels there must be a corresponding variation in the moulding sands employed.

If a sample of naturally-bonded moulding sand be examined under the microscope, it will be seen that the sand consists of grains which are covered with a thin layer of bond. The grains, by chemical analysis, are found to consist of silica or quartz, whilst the bond is generally of a ferruginous or of an aluminous nature. The quartz is the refractory constituent whilst the bond has a much lower fusion point. It is desired that the sand used for producing steel castings will give a good clean and smooth surface to them and will at the same time strip readily and will not burn into the castings; it is upon the refractoriness of the sand that the latter depends, whilst it is permeability and grain size that influence the former. A low casting temperature assists in obtaining a good strip, but would not necessarily assist in producing a smooth surface.

A moulding sand must possess adequate mechanical strength in the green or undried condition as well as in the dried state. From a moulder's point of view, plasticity is a very important consideration, and although moulders vent their moulds to allow the escape of gases during casting, the permeability of the sand used assists in the passage of mould gases and is a property which is most important. It has been found that the water or moisture content has a profound influence upon the properties of naturally-bonded sands, those which are most affected being the permeability and compression strength. It is an essential requirement if regular and uniform sands are to be delivered from the sand-preparation plant that the moisture content be kept under strict control.

It will be realised that upon weather conditions will to some extent depend the moisture content of incoming sands from the sand quarries. It is recommended that all incoming sands be dried before being mixed and milled in accordance with shop requirements, and that the necessary water to give the desired content be added during the milling operation.

The grain size should be uniform to give good permeability, whilst the grain size selected should be such as to assist in giving a smooth surface; for instance, small light steel castings will generally be produced from sand having a smaller grain size than will be employed for larger and heavier castings. The increased permeability which is obtained from larger grain size sand is made use of when producing steel castings from green-sand moulds. The water vapour which is formed when the molten steel comes in contact with the mould surface rapidly passes through the pores of green-sand moulds if the sand grain size be suitable, whereas blown castings would result if too fine a sand were employed.

Artificially-bonded moulding sands generally consist of a silica sand bonded with linseed oil or some similar oil which hardens by oxidation. It is considered desirable also to add compounds such as cornflour or sulphite leys to give strength and rigidity to the sand and moulds in the undried condition and until the oil hardens. Routine testing of all incoming and prepared moulding sands is an essential requirement in any steel-foundry control system, and the sand-testing equipment recommended by the British Cast Iron Research Association and the Institute of British Foundrymen will give valuable data to assist in this direction.

Moulding, Coremaking, Drying and Closing

The nature of the designs and numbers required, etc., are factors which influence the moulding methods employed. For large quantities of small or medium-sized steel castings, machine-moulding methods will assist to give quick deliveries, but these methods would hardly be justified or be employed for producing heavy and intricate steel castings such as turbine castings and ships' hull castings.

The provision of suitable tackle and facilities for accurate work has received much attention of late, which has resulted in considerable advances in moulding-box design. Much can be written to justify the use of steel moulding boxes in preference to those made in iron, and many steel foundries are now using the steel boxes.

Pneumatic rammers in both the moulding and coremaking sections have assisted in relieving the monotony of ramming, particularly in big jobs. Due attention must be paid to efficient ramming, particularly in the case of green-sand moulds.

It will be appreciated that, owing to the heavy ferrostatic pressures exerted by molten steel, it becomes necessary to take precautions against the possible washing of the mould surface during casting. The method usually adopted is to reinforce the mould face with large flatheaded nails, and these nails, being in the mould and not in the castings, are of no detriment to the final product.

It is the aim of the steel founder when making and casting to do all possible to run the steel into the mould as easily as possible, and with this object in view a mould is so made that the molten metal can enter at several points; this avoids heavy rushes of metal which might wash the mould surface away, even in spite of the precaution mentioned earlier. Such surface washing, if it occurred, would result in dirty castings which would have to be scrapped.

Another precaution taken is that of venting. When the molten steel enters the mould the gases present naturally expand rapidly due to the radiation of heat from the molten steel, and these hot gases must be allowed to escape from the mould as quickly as possible in order to avoid blown castings. The nailing of the mould surface and venting are both done during the moulding operation. In a similar manner it is most necessary to vent cores efficiently and to ensure that the vent holes match up with those left in the mould.

Contraction

One of the most important problems which confront the steel founder is that of contraction. It is, of course, a well-known fact that metals expand and contract, but the great influence of these physical facts to the foundrymen is seldom appreciated. Steel at a temperature just below its freezing point has little tensile strength, so that if the mould offers much resistance to the contracting steel during the cooling stages the metal may actually rupture, and the resultant casting will contain "pulls" or "tears." If the resistance of the mould to the contracting metal be not sufficiently large to cause pulls, it may be great enough to cause distorted castings. Mould construction must therefore be considered with this in mind—and the use of lightening pockets, or pockets filled with some easily collapsible material is of great assistance in avoiding pulls, etc.

The correct designing and positioning of the feeding heads employed is another factor which greatly affects the quality of steel castings. The importance of this matter will be appreciated when it is stated that, for some designs, it is necessary to employ a weight of steel greater than the weight of the castings for feeding purposes in the form of "heads." If the feeding material be insufficient in quantity for the particular casting, the resultant product will be found to contain shrinkage defects in the form of "pipes" or "draws."

It is the aim of the steel founder in considering a particular casting to employ an adequate reservoir of molten steel that will give a sound casting free from shrinkage defects and yet be true to shape. It is possible for the feeding heads, unless precautions are taken, to set up strains in the casting, because they tend to hold the contracting casting unless the mould between the feeding heads be lightened out. The shape of the feeding heads can influence their efficiency both as regards their function as a reservoir of molten steel and the resistance they set up to contraction.

For high-class work it is considered necessary to dry all moulds used for steel castings. Drying stoves fitted with recording pyrometers are generally employed for small and medium-sized work made in boxes, but in the case of large jobs made in the floor or in pits special drying units are used.

* Paper read before the East Midlands Branch of the Institution of Mechanical Engineers.

In order to avoid cracking the surface of the moulds during drying, it has been found advisable to use only moderate heat coupled with a quick change of atmosphere. In order to allow of this, modern drying stoves are fitted with fans which assist in giving a large delivery of air and so a frequent change of atmosphere in the stoves. It is necessary to employ a different drying temperature for naturally-bonded sand moulds and cores from that employed for accelerating the hardening of oil-bonded sand moulds and cores.

The closing of moulds calls for considerable skill, and in the high-class foundries it is customary to employ men to check over the

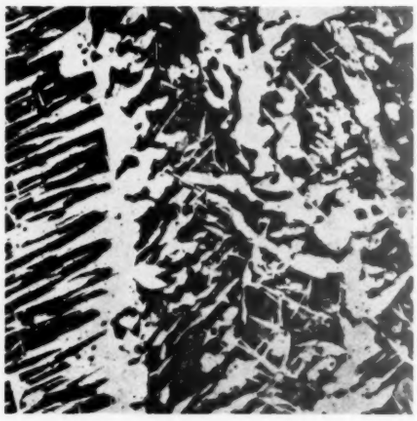


FIG. 1.—STRUCTURE OF 0.20 PER CENT. CARBON STEEL, "AS CAST." × 50.

dimensions of moulds at this stage. This precaution ensures that the final castings will be correct to drawing, and assists in the avoidance of mistakes of omission (such as leaving out of cores, etc.). The closed moulds are then ready for casting.

Liquid Steel

The preparation of molten steel for castings of suitable characteristics and of correct chemical composition is a subject for a Paper in itself. It may be sufficient for the present purpose if the foundry requirements be stated. Steel of sufficient temperature and possessing high fluidity is obviously desirable. Freedom from non-metallic inclusions and from dissolved gases, and, of course, correct chemical composition, are other requirements.

Molten steel which has been highly refined must be treated with the utmost care during the pouring stages. If the ladle practice employed is not of the best, dirt can be picked up easily and the castings poured from such steel would be of inferior quality. The use of high-quality refractory ladle-lining materials is fully justified in view of the importance which must be attached to clean steel. Pouring molten steel over the lip of a ladle gives a close control over the pouring speed, but unless precautions are taken particles of slag may be carried over the lip along with the molten steel, and the slag will be found later entrapped in the castings.

The use of stoppered ladles overcomes this particular trouble, but it is not so easy to control the pouring rates. Stopper nozzles and ends are a frequent cause of trouble and considerable skill is required in setting the stoppers if freedom from running nozzles is to be secured. Close control over the pouring temperature helps considerably in making for a uniform final product. The use of optical pyrometers as a check upon the temperature of the liquid steel is an essential part of the control system.

Stripping

When handling alloy steel castings it becomes necessary to employ different stripping methods from those employed for ordinary carbon steel castings. Some of the alloy steel castings require to be knocked out from the moulds whilst still at temperatures close to 900 deg. C., whilst others can be safely allowed to cool off to 600 to 700 deg. C. After the hot castings are cleaned free from adhering sand, depending upon their qualities they are put into annealing furnaces standing at suitable temperatures, and are given a heat-treatment to put them into a safe condition. If the foregoing were omitted, and the castings were allowed to cool down in the moulds to room temperature, the resultant castings would probably "clink."

The removal of the feeding heads and runners is sometimes carried out whilst the castings are still hot and immediately they are free from sand; before they are put into the treatment furnaces. After the preliminary heat-treatment which makes the castings safe to handle they are then thoroughly fettled and are next given a thorough annealing treatment. The object of this is twofold, first to bring about a refining of the grain of the steel and then to eliminate casting stresses.

The rate of heating up to the soaking temperature must be controlled so as to avoid setting up stresses which might break the castings. Further, the soaking temperature and time selected should be suitable for the composition of the steel and the thickness of the casting. Figs. 1 and 2 show photomicrographs of ordinary carbon steel in the as-cast and treated conditions, and give an idea of what is accomplished by an efficient annealing treatment. To bring out the full properties of the steel it becomes necessary to give the castings further treatments, such as water quench and temper, oil harden and temper, etc., according to the type and quality of the steel used. To ensure that the castings receive the treatment laid down, the furnaces used should permit of close control over temperature and of furnace atmosphere.

PROPERTIES OF STEEL CASTINGS

Carbon Steels

A carbon steel containing 0.20 per cent. C is generally used for structural and ordinary engineering mild-steel castings. It possesses good ductility associated with approximately 28 tons per sq. in. tensile strength. For ordinary transmission gears and for parts subject to wear and abrasion a higher carbon content is generally used. A carbon steel containing 0.40 per cent. carbon has been found to give satisfactory results in service for such purposes. Anvil blocks, hammer tools, etc., are generally produced from a high-carbon cast steel with 0.60 to 0.80 per cent. C. The usual range of carbon steel castings is shown in Table I.

The pattern contraction allowance usually made for carbon steels is $\frac{5}{16}$ in. per ft. The requirements for steel castings of the British Standard Institution can be satisfactorily met by the use of carbon steel castings containing 0.20 per cent. C for the ordinary grade and 0.40 per cent. for the wearing surface requirements, providing that the castings have been properly heat-treated so as to develop their full properties.

At temperatures below the normal the shock-resisting qualities of ordinary mild carbon steel castings are reduced, so that it becomes necessary to consider carefully the design of components for such use. Reference will be made to this point later, when dealing with nickel steels. For use at high temperatures mild carbon steel castings have during the last few years been displaced, and carbon-molybdenum steels are now generally employed.

Carbon-Manganese Steels

These are generally of two types (see Table II), one containing 0.25 per cent. C and 1.40 to 1.60 per cent. Mn, and the other 0.45 per cent. C and 1.30 to 1.50 per cent. Mn. They are used for purposes where a combination of high strength and toughness is essential.

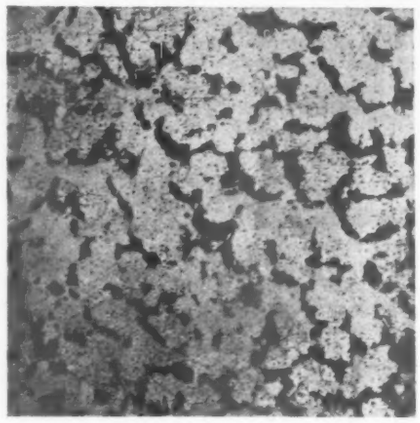


FIG. 2.—STRUCTURE OF 0.20 PER CENT. CARBON STEEL AFTER ANNEALING. × 50.

High-strength structural castings have been produced from the 0.25 per cent. C type of steel, and the subsequent results in service have fully justified the selection of such a steel. Truck side frames and bogie bolsters, knuckles, etc., are examples of the reduction in weight made possible by the use of such a high-strength steel. Excavator teeth produced from the higher carbon grade in the oil-hardened and tempered condition for some special purposes have proved to be superior to teeth made from austenitic manganese steel.

In the absence of conditions which assist adequate work-hardening it will probably be found that a naturally hard steel of this type will prove to be a valuable material. On the Continent and in the U.S.A. turbine casings and valves for steam services have been produced from a carbon-manganese steel (C 0.25 per cent., Mn 1.50 per cent.) but in this country a carbon-molybdenum type of steel is generally preferred for the purposes stated.

TABLE I.—*Properties of Carbon Steel Castings.*

Carbon. Per cent.	Heat-treatment.	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	R.A. Per cent.	Brinell.
0.20	Annealed 900/920 deg. C. ..	26/30	13/17	35/20	55/30	110/126
0.30	,, 890/900 deg. C. ..	29/34	14/18	28/18	45/24	121/149
0.40	,, 860/880 deg. C. ..	35/40	18/21	20/15	30/18	159/179
0.50	,, 840/860 deg. C. ..	45/50	18/21	20/15	30/18	196/225
0.75	,, 810/830 deg. C. ..	50/55	18/21	20/15	30/18	225/255

TABLE II.—*Properties of Carbon-Manganese Steels.*

Analysis.	Heat-treatment.	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	R.A. Per cent.	Brinell.
C 0.25 / Mn 1.50	Fully annealed	35/40	18/22	25/20	40/30	160/180
C 0.45 / Mn 1.35	Fully annealed, oil-hardened and tempered.	40/50	23/30	20/15	30/20	183/225

Nickel-Manganese Steels

The addition of from 1 to 1½ per cent. nickel to the type of steel previously mentioned gives a further improvement in the physical properties obtained. They are:—

Analysis.	Heat-treatment.	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	R.A. Per cent.	Brinell.
C 0.25 Mn 1.50 Ni 1.50	Fully annealed, hardened and tempered.	40/45	23/25	23/18	33/28	183/207

Locomotive side-frames have been produced from this grade of steel.

The pattern contraction allowances for carbon-manganese and for nickel-manganese steels of the composition given are from $\frac{5}{16}$ in. to $\frac{7}{32}$ in. per ft. depending upon the manganese content.

Nickel Steels

In the form of castings which have been suitably heat-treated, nickel steels possess high tensile strength and yield point with very good ductility, as determined by elongation and reduction of area, and excellent resistance to shock and impact. A typical statement would read:—

Analysis.	Heat-treatment.	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	R.A. Per cent.
C 0.20 Ni 3.00	Annealed 950/980 deg. C., air-cooled from 850 deg. C., tempered at 650 deg. C.	35/40	23/27	30/18	50/35

Nickel steel castings have been found to possess good physical properties at temperatures below the normal and to retain their resistance to shock and impact much better than ordinary carbon steel castings at sub-normal temperatures. Ships' propellers for service in the Arctic regions have been made from this material. Highly stressed rolling-mill and excavating machinery castings requiring high resistance to fatigue and impact are other examples of the application of nickel steel castings. The pattern contraction allowance made for nickel steel containing up to 3.0 per cent. nickel is $\frac{5}{16}$ in. per ft.

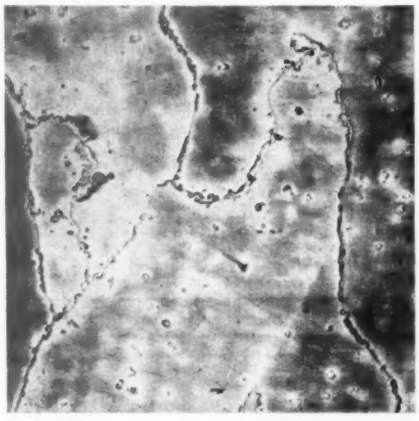


FIG. 3.—STRUCTURE OF MANGANESE STEEL, "AS CAST." × 200.

Nickel-Chrome Cast Steel

This material generally contains about 0.30 to 0.35 per cent. carbon and is of two types, the first having 1.5 to 2.0 per cent. nickel and 0.6 to 0.90 per cent. chromium, whilst the second contains about 3.0 per cent. nickel and 1.50 per cent. chromium. The properties of the two types are given in Table III.

Cast-steel excavator gears, tractor, crane and winch parts are suitable applications for these steels. Very heavy-duty rolling-mill gears have been produced from the high-nickel, high-chrome type. Excavator bucket fronts, lips and teeth and oil-well machinery parts have been made from the first variety and have replaced austenitic manganese steel castings for some purposes. The castings, as will be seen from a close study of the figures given, possess excellent physical properties. The pattern contraction allowance made for these steels is $\frac{5}{16}$ in. per ft.

Nickel-Chrome-Molybdenum Steel Castings

These are usually made from a steel containing 0.30 to 0.40 per cent. C, 1.50 to 2.00 per cent. Ni, 0.60 to 0.90 per cent. Cr and 0.30 to 0.40 per cent. Mo, and are used for purposes where high strength and resistance to wear are required. Examples of this are excavator gears and racks. Turbine casings and extrusion press castings have been made from this type of steel, for its physical properties are excellent both at room temperatures and at high temperatures. Typical properties are:—

Analysis.	Heat-treatment.	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	R.A. Per cent.	Brinell.
C 0.35 Ni 1.65 Cr 0.80 Mo 0.35	Double-annealed, air-hardened and tempered.	55/60	40/45	18/12	35/20	250/275

The above properties are for tests at room temperatures, whilst the following give those obtained at high temperatures:—

	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	R.A. Per cent.
Short-time tensile tests at:				
300 deg. C.	53.4	39.6	12	20
400 deg. C.	49.9	37.6	13	28
450 deg. C.	45.0	35.6	17	34

The pattern contraction allowance made for this steel is generally $\frac{5}{16}$ in. per ft.

TABLE III.—*Properties of Nickel-Chrome Steels.*

Analysis.	Heat-treatment.	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	R.A. Per cent.
C 0.30 Ni 1.75 Cr 0.8	Fully annealed, oil-hardened and tempered.	40/50	25/35	20/15	30/20
C 0.30 Ni 3.00 Cr 1.50	Do. do.	50/60	—	—	—

Carbon-Molybdenum Steels

These steels are now in regular use for service conditions involving temperatures associated with steam generation and use, such as valves, steam chests, turbine casings, etc. The composition generally employed is 0.20 to 0.25 per cent. C, 0.80 per cent. Mn and 0.50 to 0.80 per cent. Mo, although occasionally a carbon content of 0.30 per cent. may be employed.

The properties when tested at room temperatures obtained are:—

Analysis.	Treatment.	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	R.A. Per cent.
C, 0.20 Mn, 0.80 Mo, 0.6	Fully annealed	32/38	17/26	26/20	45/30

At high temperature the following results may be secured:—

	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	R.A. Per cent.
300 deg. C...	40	20	14	24
400 deg. C...	34	18	24	40
450 deg. C...	33	18	31	54
500 deg. C...	29	17.5	34	69
550 deg. C...	25	16.7	36	77

The pattern contraction allowance is usually $\frac{7}{32}$ in. per ft.

Manganese-Molybdenum Steels

These steels are employed for special resistance to shock and impact, such as is encountered in pile-driving equipment. The general analysis employed is 0.25 to 0.28 per cent. C, 1.40 to 1.60 per cent. Mn and 0.50 per cent. Mo, which in fully treated condition gives a M.S. of 40 to 50 tons per sq. in.; Y.P., 25 to 35 tons; E., 20 to 15 per cent., and R.A., 30 to 20 per cent. The pattern contraction allowance for this material is $\frac{1}{4}$ in. per ft.

AUSTENITIC MANGANESE STEEL CASTINGS

Manganese steel castings are usually made from steel of the following range in chemical composition:—C, 1.0 to 1.4; Si, 0.30 to 1.00; Mn, 10.0 to 14.0; S, 0.05 per cent. maximum and P, 0.10 per cent. maximum. The steel may be made either by mixing low carbon steel (produced in the open-hearth furnace or by a side-blown Bessemer converter) with ferro-manganese in such proportions as to give the desired chemical compositions, or in the basic electric furnace.

If the basic electric furnace be used it becomes possible to use heads and runners from manganese steel castings as part of the charge, and so to recover some of the manganese contained in the scrap. Variations in chemical composition to meet particular service conditions are sometimes made. Some makers aim at keeping the manganese content at not less than 11 per cent. and also the carbon content *below* 1.3 per cent., because the heavier castings tend to crack during the cooling stages in the mould if the carbon content exceeds that figure.

Silicon can be used to increase the fluidity of the steel, and so aids the production of thin and intricate castings. Some makers hold the view that silicon in amounts up to 1.5 per cent. actually increases the wear-resisting qualities of the steel. Sulphur is usually present in such small quantities that its effect can be ignored, whilst phosphorus has little effect upon the toughness or wear-resisting qualities of manganese steel in amounts up to 0.10 per cent.

Manganese steel containing approximately 1.15 per cent. carbon and 13.0 per cent. manganese has a melting point close to 1,350 deg. C. These steels have a high coefficient of expansion and contraction, and the usual contraction allowance made on patterns is $\frac{5}{16}$ in. per ft.

Compared with carbon steels in the liquid condition, manganese steel possesses remarkable fluidity, and it is usual to pour this type of steel from bottom-pouring ladles. The use of magnesite nozzles in such ladles has been found to give greater efficiency than is obtained by the use of ordinary fireclay nozzles. Liquid manganese steel has a severely erosive effect upon the lining of the ladles, and a high-alumina firebrick has been found to give the best results.

The correct positioning and shape of the feeding heads is a very important consideration in the successful production of manganese steel castings. Because of the high contraction of the steel, it is essential that the feeding heads be of adequate size so as to give sound castings. Manganese steel castings which have not been properly fed and which contain shrinkage effects invariably crack during the heating prior to quenching in water.

FIG. 4.—STRUCTURE OF MANGANESE STEEL, HEAT-TREATED AND WATER-QUENCHED. × 200.

The feeding heads which it is necessary to employ to ensure sound castings are usually removed before the manganese steel castings are heat-treated. This is done by the use of the oxy-acetylene torch, and the operation must be carried out with considerable care so as to avoid setting up severe stresses in the castings by local overheating, and so cause cracking. In the same way, cleaning the manganese steel castings from the adhering sand must be done with care.

In the "as-cast" condition, manganese steel castings are extremely brittle, this brittleness being due to the presence of the free cementite round the grain boundaries, as shown in Fig. 3. To ensure the complete solution of this cementite, and to fix the steel in the austenitic condition, the manganese steel castings are heated to a temperature of about 1,040 deg. C. and then quenched in cold water. The resulting microstructure is shown in Fig. 4.

It has been noted already that manganese steel has a high coefficient of expansion and contraction, and this characteristic, combined with the fact that the thermal conductivity is low, makes it necessary to heat the castings very slowly so as to avoid setting up thermal stresses. If the castings be of complex design and the rate of heating be too rapid, the thermal stresses set up in them may be so great that cracking actually takes place. The efficiency of the feeding heads can be increased if the head bushes are used hot and are placed on the moulds just prior to casting. The high contraction of manganese steel makes it necessary that the mould construction employed be such as to reduce mould resistance to a minimum.

The incorporation of lightening pockets aids in preventing distorted castings. The sands used in making the moulds must be highly refractory and of good permeability, and adequate venting of the moulds so as to permit the escape of mould gases is necessary. The position of the down runner and of the ingates is another important factor, and should be carefully considered. As mentioned earlier, admitting the steel in as many points as possible helps to reduce to a minimum the cutting action of the steel on the mould surface. Intricate manganese steel castings may be knocked out of the mould whilst still hot and placed in an annealing furnace standing close to the temperature of the casting.

Simple and straightforward manganese steel castings are usually allowed to cool down to room temperature before they are removed from the mould. The rate of heating usually employed for manganese steel is about 50 deg. C. per hour. The castings are held at 1,040 to 1,050 deg. C. for a sufficient period of time to ensure the complete solution of the cementite, and, if this is not done, the full toughness and strength of the steel are not obtained. The following are the physical properties of manganese steel in the fully austenitic condition:—

Specific gravity, 7.88; *specific heat*, 0.177 cals. per gramme; *electrical resistivity*, 65 to 75 microhms per cm. cub.; *thermal conductivity*, 0.03 to 0.025 cals./sq. cm./deg. C. per cm.; *coefficient of expansion*, 20 deg. to 100 deg. C., 0.000018.

Tensile tests taken on pieces cut from castings have given the following results:—Maximum stress 59.3 tons per sq. in. with 64 per cent. elongation and 38 per cent. reduction of area, and 58.06 tons per sq. in. with 52 per cent. elongation and 91 per cent. reduction of area, combined with a bend test of 180 deg. without fracture on a test-piece 2½ in. wide and ⅝ in. thick. The Brinell hardness of austenitic manganese steel castings is generally from 180 to 200, but this hardness can be rapidly increased by cold work.

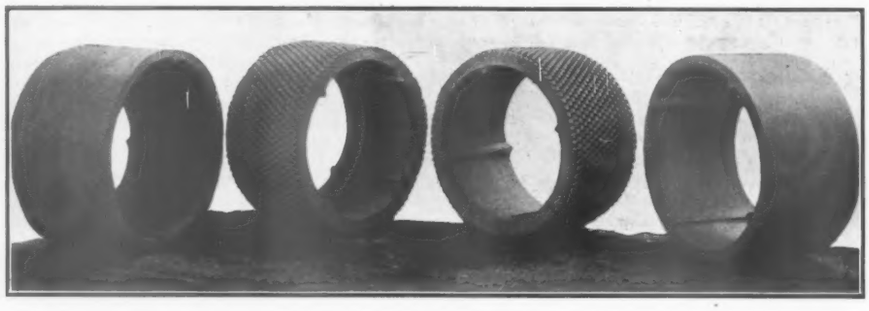


FIG. 5.—PLAIN AND CUBED CRUSHING ROLLS IN MANGANESE STEEL.

If the surface of an austenitic manganese steel casting be hammered it can be increased in hardness to 400 to 500 Brinell. It is this particular property of "work-hardening" which is valuable and gives the resistance to wear of manganese steel castings when the wear is associated with hammering and pounding.

Designs

The designing of manganese steel castings is a very important matter, because austenitic manganese steel is comparatively soft and ductile, and in the case of ball-mill liners, manganese steel tends to spread under the peening action of the balls. It becomes necessary therefore to take precaution against this spread resulting in the badly-distorted linings in service which might interfere with the normal mill action. The incorporation on the face of the plates of grooving or chequering is one method employed; the grooves tend to be filled up in

(*Concluded on page* 150.)

FIG. 6.—CAST MANGANESE STEEL BUCKET PRIOR TO DESTRUCTION TEST.

FIG. 7.—MANGANESE STEEL BUCKET AFTER TEST.

FIG. 8.—BUCKET SHOWN IN FIG. 7 SECTIONED TO DEMONSTRATE SOUNDNESS.

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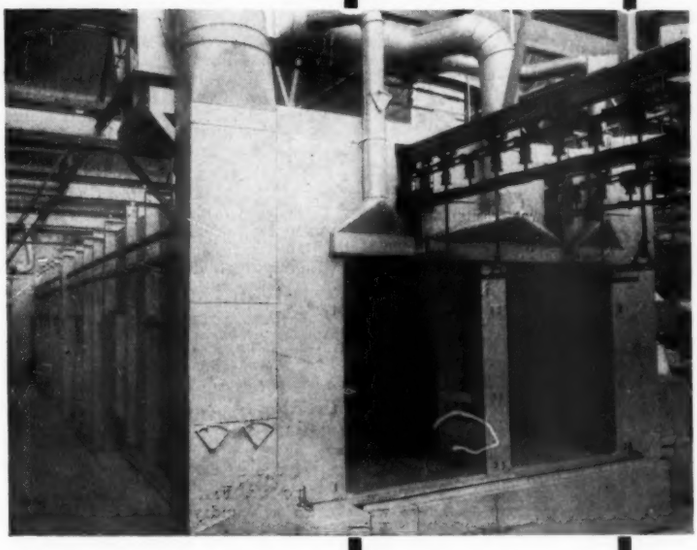

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The Week's News in Brief

Trade Talk

THE L.M.S. RAILWAY have placed an order with William Denny & Bros., Limited, Dumbarton, for a twin-screw motor vessel.

THE WOLSINGHAM STEEL COMPANY, LIMITED, have recently delivered to the Wallsend Shipyard of Swan, Hunter & Wigham Richardson, Limited, a cast-steel ship's rudder weighing 20 tons.

ALEX. WILSON (ABERDEEN), LIMITED, have received a contract for eight portable air-compressors for the New Zealand Government, and an order from the War Office for four special cranes for export.

THE ANNUAL STAFF DANCE of Messrs. Robert Taylor & Company, Muirhall Foundry, Larbert, was held last week. Mr. Robert Taylor (managing director) presided at the dinner which opened the evening.

THE DIRECTORS of William Asquith, Limited, machine-tool makers, of Halifax, propose to reduce the issued capital from £329,188 to £247,605 by reducing each of the 217,556 15s. ordinary shares to 7s. 6d. each.

FULL PRODUCTION of aluminium was resumed at the Kinlochleven factory of the British Aluminium Company, Limited, on February 2. Since the beginning of November last production had to be reduced owing to water shortage in the Blackwater Dam.

THE PARTNERSHIP between Messrs. William Murray and Robert Arnold Murray, carrying on business as brassfounders and engineers at Walkergate, Newcastle-upon-Tyne, under the style of John Mills & Sons, has been dissolved by mutual consent. Debts will be received and paid by Mr. William Murray, who is continuing the business.

VICKERS, LIMITED, and their subsidiary companies, who have been giving consideration to the introduction of a pension and life assurance scheme for the members of the staffs, have arranged schemes which, it is hoped, will come into operation on March 1 next. The members of the staffs who will be offered participation in the schemes number between 6,000 and 7,000.

Personal

MR. JAMES SMITH, foundry manager of R. Russell & Sons, Limited, Peel Foundry, Derby, has retired after 37 years' service on account of ill-health.

MR. JAMES IRWIN (of J. J. McKeown, iron-founders, of Belfast) was re-elected President of the Engineering and Allied Employers' Northern Ireland Association, at the annual meeting in Belfast last week. Mr. Arthur F. Shillington (Musgrave & Company, Limited) was re-elected Vice-President.

MR. R. W. THORNTON has been appointed a director and chairman of the Glacier Metal Company, Limited, following the death of Mr. C. W. Findlay, managing director. Messrs. M. Melhuish and W. B. D. Brown become joint managing directors, and Mr. F. E. Maer, works manager, has been appointed a director.

MR. D. J. REESE, of the International Nickel Company, Bayonne, N.J., is the first chairman of the newly-organised Metropolitan Chapter of the American Foundrymen's Association, which caters for foundrymen in the New York and New Jersey metropolitan district. Mr. T. J. Wood, of the Robins Conveying Belt Company, Passiac, N.J., is the secretary.

Obituary

MR. CHARLES DOUGLAS, who was associated with the Larbert Foundry of Dobbie, Forbes & Company, Limited, for 38 years, being cashier for 20 years, has died at the age of 68.

MR. MITCHELL FEARNSIDE, member of a family well known in foundry circles in Keighley, died on February 2, at the age of 77. He was associated with Samuel Fearnside & Sons, and later with Stephen Stell & Company, but had been retired some years.

Contracts Open

Freshwater, February 14.—Providing and laying 1,600 yds. of 3-in. and 4-in. dia. spun-iron mains, for the Isle of Wight Rural District Council. Mr. W. E. Blizard, engineer, Lemon & Blizard, Castle Lane, Southampton. (Fee £2 2s., returnable.)

Great Ouseburn, February 25.—6,300 yds. of 5-in., 7,000 yds. of 4-in., 11,600 yds. of 3-in. and 1,400 yds. of 2-in. dia. spun-iron water mains, for the Rural District Council. Mr. H. S. Thompson, clerk, Council Offices, Boroughbridge, Yorks. (Fee £5, returnable.)

Wolverhampton, February 18.—P.B.J. wires and cables; hard-drawn copper conductor; welded and solid-drawn conduit; compounded insulating tapes; iron-clad house service terminal boxes and fuses; cast-iron street lamp standards; transformers; metal-clad switchgear, 350, 250 and 150 M.V.A. rupturing capacity, etc., for the Town Council. Mr. T. A. G. Margary, 83, Darlington Street, Wolverhampton.

Company Meeting

The annual meeting of Beans Industries, Limited, was held on February 2 at Birmingham. MR. VICTOR RILEY (chairman) said that the board had continued their policy of taking every opportunity of installing modern plant in order to achieve the most economical production and to enable the company to extend its activities in the foundry and general engineering world. The foundry, which was well equipped at the time of its acquisition by the company, had had considerable sums spent upon it in improving and modernising both its layout and equipment. The policy had already borne fruit. The same policy of expansion and improvement had been adopted as regarded the general engineering shops.

Company Reports

Bradley & Foster, Limited.—Interim dividend on the ordinary shares of 4 per cent.

Glacier Metal Company, Limited.—Dividend on the 5½ per cent. cumulative preference shares for the half-year ending February 28.

C. Akrill & Company, Limited.—Dividend on the ordinary shares of 2s. per share, free of tax, and a bonus of 1s. per share, free of tax, in respect of the year ended December 31 last.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Johnson & Allen, Limited, 23, Granville Street, Sheffield, 2.—Capital, £2,000. Manufacturers of welding electrodes, etc. Directors: H. R. S. Johnson and A. Allen.

Forthcoming Events

FEBRUARY 14.

Institute of Metals (Scottish Section):—Joint meeting with Institution of Automobile Engineers (Scottish Centre). "Some Notes on Aluminium Alloys in Road Transport," Paper by G. Mortimer, at Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, at 7.30 p.m.

FEBRUARY 17.

Institution of Mechanical Engineers (Midland Branch):—"Contributions of the Engineer towards Metallurgical Progress," Paper by P. Jump, at James Watt Memorial Institute, Great Charles Street, Birmingham, at 6.30 p.m.

Institute of British Foundrymen

FEBRUARY 16.

Lancashire Branch:—"Some Points in Non-Ferrous Foundry Practice," Paper by A. Phillips, at the Engineers' Club, Manchester, at 7.30 p.m.

FEBRUARY 17.

East Anglian Section:—Annual dinner at Crown and Anchor, Ipswich, at 7 p.m.

FEBRUARY 19.

Bristol Section:—"Green-sand Moulding," Paper by F. Whitehouse, at Merchant Venturers' College, Bristol, at 7 p.m.

Falkirk Section:—"Problems in Light Castings," Paper by N. A. W. Erskine, at Temperance Café, Lint Riggs, Falkirk, at 6 p.m.

Production and Properties of Steel Castings

(Concluded from page 148.)

service but the contour of the plates remains unaffected. In the case of bottom tumbler rims working on tin dredges it is now customary to arrange for grooving on the outside to take up any surface spread which might occur. This is shown in Fig. 5. Clinker and ore shutes are other instances where this device might be employed with success.

Austenitic manganese steel castings cannot generally be made over thicknesses of about four inches; heavier sections than this generally crack during treatment. Reference has been made earlier to the high coefficient of expansion and contraction and to the low thermal conductivity of the steel, and these physical properties naturally must be borne in mind when considering the design of castings to be made in this type of material. As far as possible quick and extreme changes in section should be avoided.

Figs. 6 to 8 show, however, that sound and reliable castings can be made in austenitic manganese steel if proper precautions based on sound scientific knowledge be employed. They show the destruction test of a manganese steel bucket casting and Fig. 8 shows the casting cut up to prove soundness.

Machining

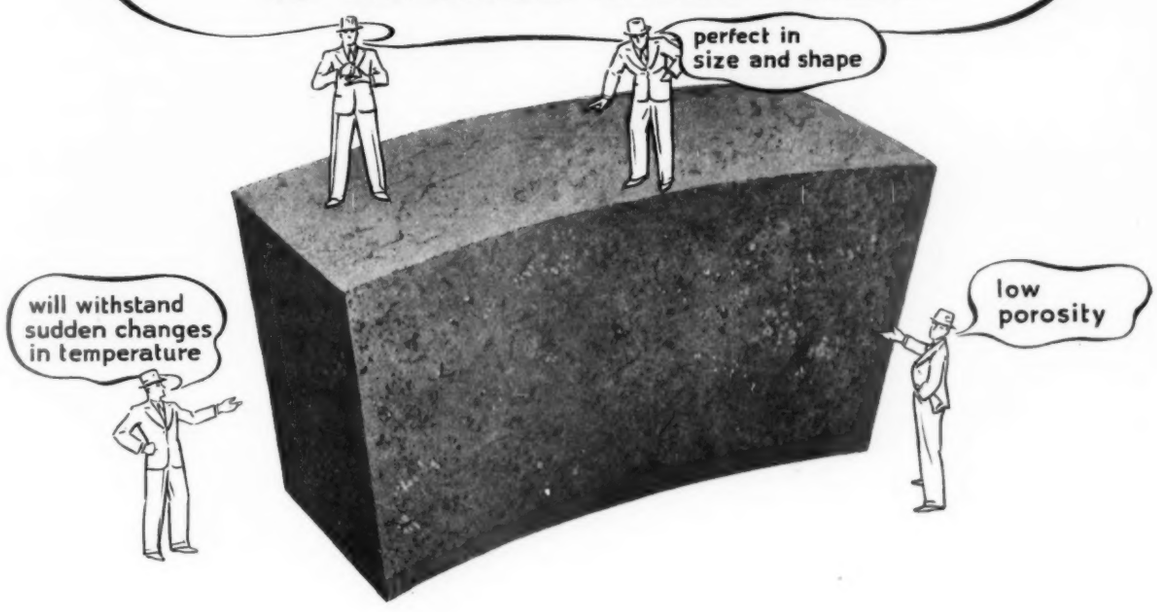
The peculiar work-hardening property of austenitic manganese steel made it a material which until recently was considered unmachinable commercially, and grinding was usually resorted to. The recent development of carbide-tipped tools has been of great assistance and now manganese steel castings are being regularly machined and such machining is quite economic. The correct selection of grit and grade of the stones used for grinding manganese steel has been the subject of much research work, and the use of bakelite-bonded stones has proved their value for this particular type of steel.

On heating, ordinary manganese steel in the austenitic condition tends to lose its toughness at comparatively low temperatures, so that it is not advisable to use it for purposes when the service conditions are associated with much heat. There has been developed a nickel-manganese steel containing C, 0.6 to 0.7; Mn, 12.0 to 13.0, and Ni, 3.0 to 5.0 per cent. which retains its toughness at higher temperatures than does ordinary manganese steel. The heat-treatment given to this steel is an ordinary air-cool from about 1,050 deg. C., and this gives an austenitic structure similar to that obtained by the water-quench in the case of ordinary manganese steel. The nickel-manganese steel has not quite the same resistance to wear as that obtained from the standard manganese steel, but it is a valuable material for special purposes.

Welding rods made of nickel-manganese steel are sometimes used for building up worn manganese steel castings, and such welds have proved to be quite reliable in subsequent service. Tensile tests taken on deposited weld metal show the welded material to have a strength of 45 to 50 tons per sq. in. with good ductility. Extreme care is required, however, with the welds, and precautions against overheating are necessary.

The author would like to express to the chairman and directors of T. Firth & J. Brown, Limited, and particularly to Dr. W. H. Hatfield, F.R.S., The Brown Firth Research Laboratories and to Mr. C. W. D. Townsend, the General Manager of the Scunthorpe Steel Foundry, his keen appreciation for permission to publish this Paper and for considerable assistance and encouragement received.

Reliability - is certainly the word to describe these bricks



You can safely rely on the firebricks supplied by the General Refractories Group of Companies giving you satisfaction in every respect. They withstand high temperatures and sudden changes of heat without melting or splitting, and their low porosity enables them to resist abrasive forces and slag action. The utmost care is taken in the production of both standard sizes and special shapes, so that they are always of the same high quality.

We supply firebricks from Scotland, Sheffield and Stourbridge, and can therefore provide you with exactly the right quality to suit your needs. Please write for further information.

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Telephone: *Sheffield* 31113 (6 *lines*) **GENEFAX HOUSE, SHEFFIELD, 10** *Telegrams:* "*Genefax Sheffield*"

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SCOTTISH OFFICE: 48, West Regent Street, Glasgow, C.2. Telephone: Douglas 6108 (3 lines). Telegrams: "Genefax, Glasgow." (Mr. C. A. G. Thomson).

SWANSEA OFFICE: Metropole Chambers, Wind Street. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE: 9, Albert Square. Telephone: Blackfriars 6130 Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell).

MIDDLESBROUGH OFFICE: Halifax Bldgs., Exchange Place, Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough." (Mr. J. A. Williams).

CARDIFF OFFICE: 17, Windsor Place, Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter).

Raw Material Markets

Good deliveries of iron and steel continue to be made under contracts. Most consumers are in possession of adequate supplies to enable them to maintain satisfactory working, and there is now less pressure on the makers. New business is quiet at the present time.

Pig-Iron

MIDDLESBROUGH.—Now that supplies are available in larger tonnages, producers are able to give more attention to the needs of the export market, which had to be neglected to a large extent during the whole of last year. Unfortunately, however, inquiries from abroad appear to have dried up, and little business is being placed. A considerable amount of iron is still coming into the Cleveland area from the Midlands under arrangements made when Cleveland iron was less freely available. Subject to 5s. rebate, the fixed prices of No. 3 Cleveland G.M.B. are 109s. per ton in the Middlesbrough and Falkirk zones, 111s. on the North-East Coast and 112s. on Clydeside.

The hematite market is firm. No difficulty is experienced in disposing of the full output, although the demand certainly appears to be rather less. In view of the fact that hematite is available on the Continent at prices well below British quotations, export demand is very quiet. East Coast mixed numbers are quoted at 132s. 6d., less 5s. rebate, for delivery on the North-East Coast.

LANCASHIRE.—In most instances, small stocks have been built up at the consuming plants; consequently, users are not exerting undue pressure on the producers for deliveries, although supplies are being taken up as they become available. There is little improvement to report at the light-castings and textile-machinery plants, but elsewhere activity is quite good. For delivery in the Manchester price zone, Derbyshire and Staffordshire No. 3 is quoted at 114s., with Northamptonshire at 112s. 6d. and Derbyshire forge iron at from 111s. to 113s. No. 3 Scottish foundry is at 141s. West Coast hematite is quoted at 141s., and East Coast material 140s. 6d., subject to 5s. rebate, for delivery in the Manchester district.

MIDLANDS.—This was the first district to experience easier conditions in the pig-iron market, and now very little new business is going through. Stocks at the furnaces are getting quite substantial, while consumers generally have supplies on hand. When activity at the motor works and light-castings foundries becomes on a better scale, no doubt there will be less iron available, but users do not consider it imperative to enter into new contracts at the present time. The special grades of hematite are still on the short side, but most inquiries can readily be met. Pig-iron quotations are firm only until the end of June, but prices of hematite have been fixed for the whole of the year. The demand for low-phosphorus iron is maintained on a good scale, and heavy tonnages are coming into the district from various parts of the country.

SCOTLAND.—Consumers are taking deliveries as they are despatched, but only a small amount of new business is being placed. No. 1 foundry is still quoted at 120s. 6d., with No. 3 at 118s., f.o.t. furnaces. Very little Cleveland iron is arriving here, despite the easier condition of the pig-iron market on the North-East Coast. Cleveland No. 3 foundry is quoted at 109s. f.o.t. Falkirk, and 112s. f.o.t. Glasgow, less 5s. rebate. Steelworks continue to take up heavy tonnages of hematite and basic, and they are working very satisfactorily. Prices are unchanged at 133s. for hematite mixed numbers, 107s. 6d. for Scottish basic, and 100s. for Indian and English basic, all less 5s. rebate, f.o.t. steelworks.

Coke

Although most ironfoundries have covered their requirements of coke over the winter months, they are not getting supplies freely, the producers having difficulty in fulfilling their agreements. For delivery in Birmingham and district, best Durham foundry coke is quoted at 55s. 9d., and Welsh coke at from 55s. to 62s. 6d. per ton.

Steel

While satisfactory conditions continue to rule in practically all departments of the steel industry so far as the home trade is concerned, the demand on export account fails to develop any sustained improvement. As a consequence, those branches which rely largely upon export business are not so well supplied with orders as those which serve the home trade. Nevertheless, the decline has not been sufficient to affect the price position. The demand for semi-finished steel is on a good scale, and the consuming industries, which a short time ago were suffering from a tightness in supplies, are now obtaining all the material they want, as a result of the arrangements for supplementing the British production by imports of foreign steel. In the finished steel trade, there is a strong demand in most departments. The works producing joists, plates and sections, in particular, are being pressed to the utmost to keep abreast of deliveries. In the case of some materials, orders cannot be accepted for execution in less than five or six months.

Scrap

It is reported that large supplies of iron and steel scrap are still being imported into South Wales from the United States. Recently, three cargoes, totalling 21,649 tons, were discharged at Swansea and Port Talbot. The demand is keen in this area, despite some recession in activity at the steelworks. In most other areas, too, there is a good turnover, and supplies are generally available in adequate tonnages.

Metals

The non-ferrous metal markets appear to have lost any of the benefits which might have been derived from the speculative interest which was shown at the commencement of the year, and buyers continue to pursue a very restrained policy.

Copper.—This market exhibited a somewhat firmer tone at the beginning of the week, but this was short-lived, and the outlook is still dull. New business is quiet, but consumers are taking quite good deliveries under contract, and would appear to be awaiting a more stable market before transacting further business. In the United States, consumers are believed to possess only small stocks, although no attempt is being made at the present time to take up fresh tonnages.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £39 5s. to £39 7s. 6d.; Friday, £38 10s. to £38 12s. 6d.; Monday, £38 11s. 3d. to £38 12s. 6d.; Tuesday, £38 3s. 9d. to £38 5s.; Wednesday, £39 to £39 2s. 6d.

Three Months.—Thursday, £39 10s. to £39 11s. 3d.; Friday, £38 15s. to £38 16s. 3d.; Monday, £38 16s. 3d. to £38 17s. 6d.; Tuesday, £38 7s. 6d. to £38 10s.; Wednesday, £39 5s. to £39 6s. 3d.

Tin.—According to the monthly tin statistics compiled by Mr. W. H. Gartsen (Henry Rogers, Sons & Company), the total visible supply of tin on January 31 totalled 16,831 tons, as compared with 19,614 tons on December 31. The carry-over in the Straits Settlements was 6,133 (4,388) tons, while the carry-over at the Arnhem (Holland) smelter was 2,003 (1,709) tons. In their weekly market report, Rudolf Wolff & Company state that these statistics scarcely fulfilled anticipations, for quite a substantial increase in the total visible supply had been expected. The stimulating effect of their publication on prices was, however, only slight, and was not sustained. Business during the week has to some extent been hampered by the intervention of the Chinese New Year holidays and the consequent closing of the market in the East during Monday and Tuesday. Demand on the part of consumers in this country and on the Continent continues quiet, and only moderate business has been reported in the United States, where, by reason of the uncertainty surrounding the industrial and political situation, buyers maintain a cautious attitude. The outlook in the circumstances is by no means clear, but, in view of the control which is exercised over output, important decline seems unlikely, the market being more likely to recover were the industrial and political situation generally to give any real evidence of sustained improvement.

Official quotations were as follow :—

Cash.—Thursday, £180 10s. to £180 15s.; Friday, £179 5s. to £179 7s. 6d; Monday, £180 5s. to £180 10s.; Tuesday, £178 15s. to £179; Wednesday, £181 15s. to £182.

Three Months.—Thursday, £180 12s. 6d. to £180 15s.; Friday, £179 5s. to £179 10s.; Monday, £180 5s. to £180 10s.; Tuesday, £178 12s. 6d. to £178 15s.; Wednesday, £181 10s. to £181 17s. 6d.

Spelter.—Business continues to be conducted on a day-to-day basis, and only small tonnages have been involved in recent transactions. Consumption is reported to be maintained on quite a fair scale, despite the fact that several of the major consuming industries are less active than they were. The United States zinc quotation has been cut by ¼ cent to 4.75 cents per lb.

Daily market prices :—

Ordinary.—Thursday, £14 11s. 3d.; Friday, £14 7s. 6d.; Monday, £14 2s. 6d.; Tuesday, £14; Wednesday, £14 2s. 6d.

Lead.—Although the immediate outlook is not encouraging, it is expected that a fairly strong demand will develop later in the year. Continental trade at present is rather weak, while industrial and political conditions in the United States are against any early expansion of business in that country. The American lead price has been reduced to 4.75 cents per lb.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 12s. 6d.; Friday, £15 10s.; Monday, £15 6s. 3d.; Tuesday, £14 18s. 9d.; Wednesday, £15 5s.

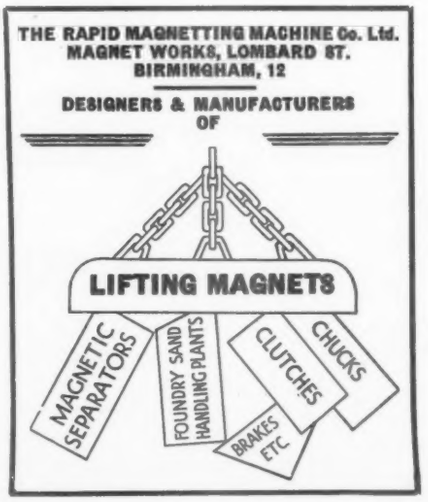
Scrap.—Dealers in non-ferrous scrap metals continue to withhold supplies pending the advent of better prices, and trade remains quiet. Price movements during the past week have shown a downward trend.

Approximate selling prices for old metal:—New aluminium cuttings, £82; rolled, £66; cast, £40; foil, £88 to £92. Copper, £37 to £40; braziery, £34 to £35. Brass (clean), £24 to £25; Zinc, £9 10s. Lead, £14 10s. Gunmetal, £39 to £40.

Notes from the Branches

Newcastle-upon-Tyne. The January meeting of the Branch, which was presided over by Mr. Colin Gresty, attracted the largest gathering of members for many years. This was due to the fact that the lecturer, Mr. Francis W. Rowe, B.Sc., of David Brown & Sons (Huddersfield), Limited, gave the first public lecture on the subject of the Randupson process. The lecture, which is to be presented later as a communication to the annual conference of the Institute, revealed the complete success the process had achieved at Penistone. Mr. Rowe showed how recent work had shortened the drying period, whilst stress was laid on the reduction of manufacturing costs. An excellent discussion followed, covering every phase of operation from the practical angle.

RICHARDSONS, WESTGARTH & COMPANY, LIMITED, of Hartlepool, have received confirmation that they have secured the contract from the Douglas (Isle of Man) Corporation for the construction of a large water-tube boiler and a number of auxiliaries for the power station.



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OUR NEXT BROCHURE WILL ANSWER THE QUESTION—IT EXPLAINS THE ADVANTAGES AS WELL AS THE DISADVANTAGES

DATE OF ISSUE—
FIRST WEEK IN MARCH

HINCKLEYS LIMITED
11, EAST PARADE CHAMBERS
SHEFFIELD. 1.

RAW MATERIALS—PRICE LIST

(Wednesday, February 9, 1938)

COPPER

	£ s. d.
Standard cash	39 0 0
Three months	39 5 0
Electrolytic	43 5 0
Tough	42 1 3
Best selected	42 11 3
Sheets	75 16 3
India	55 3 9
Wire bars	43 16 3
Ingot bars	43 16 3
H.C. Wire rods	47 6 3
Off. av. cash, Jan.	41 8 6½
Do., 3 mths., Jan.	41 12 8½
Do., Sttlmnt., Jan.	41 8 8½
Do., Electro, Jan.	45 16 0½
Do., B.S., Jan.	45 12 6
Do., Wire bars, Jan.	46 4 4½
Solid drawn tubes	12½d.
Brazed tubes	12⅝d.
Wire	8d.

BRASS

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	9d.
Rods, extd. or rlld.	6½d.
Sheets to 10 w.g.	8½d.
Wire	8½d.
Rolled metal	8½d.
Yellow metal rods	8d.
	6¼d.

TIN

	£ s. d.
Standard cash	181 15 0
Three months	181 10 0
English	181 15 0
Bars	183 15 0
Straits	183 15 0
Eastern	184 7 6
Banca (nom.)	—
Off. av. cash, Jan.	183 15 7½
Do., 3 mths., Jan.	184 1 8
Do., Sttlmt., Jan.	183 15 8¼

SPELTER

	£ s. d.
Ordinary	14 2 6
Remelted	12 0 0
Hard	11 10 0
Electro, 99.9	18 0 0
English	15 2 6
India	13 10 0
Zinc dust	21 0 0
Zinc ashes	5 0 0
Off. aver., Jan.	15 1 8
Aver., spot, Jan.	14 19 10½

LEAD

	£ s. d.
Soft foreign, ppt.	15 5 0
Empire (nom.)	15 15 0
English	17 5 0
Off. aver., Jan.	16 3 10 17/32
Aver., spot, Jan.	16 2 8½

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English 28 0	0 to 28 10 0
Do., V.M. ex-whse. 28 0	0 to 28 10 0
Rods	20 10 0

ANTIMONY

	£ s. d.
English	81 0 0 to 82 0 0
Chinese, ex-whse.	89 0 0
Crude, c.i.f.	41 0 0

QUICKSILVER

	£ s. d.
Quicksilver	12 17 3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	12 10 0
45/50%	12 0 0
75%	17 0 0
Ferro-vanadium—	
35/50%	14/- lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/9 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	6/- lb. (nom.)
Tungsten metal powder—	
98/99%	6/1½ lb. (nom.)
Ferro-chrome—	
2/4% car.	34 15 0
4/6% car.	24 5 0
6/8% car.	24 0 0
8/10% car.	24 0 0
Ferro-chrome—	
Max. 2% car.	36 0 0
Max. 1% car.	38 5 0
Max. 0.5% car.	41 0 0
70% carbon-free	10d. lb.
Nickel—99.5/100%	£180 to £185
"F" nickel shot	£165 0 0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£18 15 0 to 19 5 0
76/80% packed	£19 15 0 to 20 5 0
76/80% export	£22 0 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 10d.
Finished bars, 18% tungsten	5s. 0d.

Per lb. d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales (West)—		
Heavy steel, best	3 8 9	to 3 11 3
Mixed iron and steel	3 6 9	to 3 9 3
Heavy cast iron	3 8 9	to 3 11 3
Good machinery	3 15 0	to 3 16 6
Cleveland—		
Heavy steel, best	3 7 0	to 3 9 6
Steel turnings	2 13 0	to 2 15 6
Heavy cast iron	4 2 6	
Heavy machinery	4 10 0	
Midlands—		
Short heavy steel	4 0 0	
Light cast-iron scrap	3 2 6	
Heavy wrought iron	4 0 0	to 4 5 0
Steel turnings	2 6 3	to 2 8 9
Scotland—		
Heavy steel, best	3 5 0	to 3 7 6
Ordinary cast iron	4 5 0	to 4 6 6
Cast-iron borings	2 0 6	to 2 3 0
Wrot-iron piling	4 5 0	to 4 7 6
Heavy machinery	4 10 0	to 4 12 6

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	32 0 0
Brass	22 10 0
Lead (less usual draft)	13 10 0
Tea lead	10 0 0
Zinc	8 0 0
New aluminium cuttings	71 0 0
Braziery copper	29 0 0
Gunmetal	32 0 0
Hollow pewter	130 0 0
Shaped black pewter	90 0 0

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	111/6
,, No. 3	109/-
,, No. 4	108/-
Forge No. 4	108/-
Hematite No. 1	133/-
Hematite M/Nos.	132/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	133/-
,, d/d Birm.	144/6
Malleable iron d/d Birm.	165/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	110/-
,, No. 3 fdry.	111/-
Northants forge	107/6
,, fdry. No. 3	108/6
,, fdry. No. 1	111/6
Derbyshire forge	110/-
,, fdry. No. 3	111/-
,, fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
,, No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
,, ,, Falkirk	109/-
Scottish hem. M/Nos. d/d	133/-
Sheffield (d/d district)—	
Derby forge	107/6
,, fdry. No. 3	108/6
Lincs forge	107/6
,, fdry. No. 3	108/6
W.C. hematite	138/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	141/-
Clyde, No. 3	141/-
Monkland, No. 3	141/-
Eglinton, No. 3	141/-
Gartsherrie, No. 3	141/-
Shotts, No. 3	141/-

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

	£ s. d.	£ s. d.
Iron—		
Bars (cr.)	13 5 0	to 13 15 0
Nut and bolt iron	11 12 6	to 12 2 6
Hoops	14 2 6	
Marked bars (Staffs) f.o.t.	15 15 0	
Gas strip	14 2 6	
Bolts and nuts, ¾ in. × 4 in.	17 10 0	and up
Steel—		
Plates, ship, etc.	11 8 0	to 11 10 6
Boiler plts.	11 18 0	to 12 0 6
Chequer plts.	13 0 6	
Angles	11 0 6	
Tees	11 0 6	
Joists	12 0 6	
Rounds and squares, 3 in. to 5½ in.	11 0 6	
Rounds under 3 in. to ⅜ in. (untested)	12 0 6	
Flats—8 in. wide and over	11 9 0	
,, under 8 in. and over 5 in.	11 5 6	
Rails, heavy	11 10 6	
Fishplates	10 2 6	
Hoops (Staffs)	14 2 6	
Black sheets, 24g. (4-t. lots)	12 4 0	
Galv. cor. shts. (,,)	15 15 0	
Galv. flat shts. (,,)	18 10 0	
Galv. fencing wire, 8g. plain	19 0 0	
Billets, soft, 100-ton lots	20 5 0	
Sheet bars	7 17 6	
Tin bars	7 15 0	
	7 15 0	

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	12⅛d.
Rods	13½d.
Tubes	18½d.
Castings	15d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2½ to 1/8½
To 15 in. wide	1/2½ to 1/8½
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	37/6
Durham foundry	39/6
,, furnace	32/6 to 37/6
Scottish foundry	42/6
,, furnace	40/-

TINPLATES

f.o.b. British Channel ports.

I.C. cokes	20×14 per box	22/6
,,	28×20 ,,	45/-
,,	20×10 ,,	34 9
,,	18¾×14 ,,	24 9
C.W.	20×14 ,,	18/- to 18/9
,,	28×20 ,,	36/- to 37/6
,,	20×10 ,,	29/9 to 30/6
,,	18¾×14 ,,	21/- to 21/3

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£12 0 0	to £13 0 0
Bars-hammered, basis	£20 0 0	to £22 0 0
Bars and nail-rods, rolled, basis	£19 0 0	to £20 0 0
Blooms	£18 0 0	to £19 0 0
Keg steel	£30 0 0	to £35 0 0
Faggot steel	£20 0 0	to £25 0 0
Bars and rods dead soft st'l	£19 0 0	to £20 0 0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£ s. d.	
Feb.	3 ..	39 5 0	dec. 11/3
,,	4 ..	38 10 0	,, 15/-
,,	7 ..	38 11 3	inc. 1/3
,,	8 ..	38 3 9	dec. 7/6
,,	9 ..	39 0 0	inc. 16/3

Electrolytic Copper

		£ s. d.	
Feb.	3 ..	43 15 0	dec. 10/-
,,	4 ..	42 15 0	,, 20/-
,,	7 ..	42 15 0	No change
,,	8 ..	42 10 0	dec. 5/-
,,	9 ..	43 5 0	inc. 15/-

Standard Tin (cash)

		£ s. d.	
Feb.	3 ..	180 10 0	dec. 30/-
,,	4 ..	179 5 0	,, 25/-
,,	7 ..	180 5 0	inc. 20/-
,,	8 ..	178 15 0	dec. 30/-
,,	9 ..	181 15 0	inc. 60/-

Tin (English ingots)

		£ s. d.	
Feb.	3 ..	180 10 0	dec. 30/-
,,	4 ..	179 5 0	,, 25/-
,,	7 ..	180 5 0	inc. 20/-
,,	8 ..	178 15 0	dec. 30/-
,,	9 ..	181 15 0	inc. 60/-

Spelter (ordinary)

		£ s. d.	
Feb.	3 ..	14 11 3	dec. 3/9
,,	4 ..	14 7 6	,, 3/9
,,	7 ..	14 2 6	,, 5/-
,,	8 ..	14 0 0	,, 2/6
,,	9 ..	14 2 6	inc. 2/6

Spelter (Electro, 99.9 per cent.)

		£ s. d.	
Feb.	3 ..	18 10 0	inc. 2/6
,,	4 ..	18 5 0	dec. 5/-
,,	7 ..	18 1 3	,, 3/9
,,	8 ..	17 17 6	,, 3/9
,,	9 ..	18 0 0	inc. 2/6

Lead (soft foreign, prompt)

		£ s. d.	
Feb.	3 ..	15 12 6	dec. 2/6
,,	4 ..	15 10 0	,, 2/6
,,	7 ..	15 6 3	,, 3/9
,,	8 ..	14 18 9	,, 7/6
,,	9 ..	15 5 0	inc. 6/3

Lead (English)

		£ s. d.	
Feb.	3 ..	17 15 0	dec. 5/-
,,	4 ..	17 10 0	,, 5/-
,,	7 ..	17 10 0	No change
,,	8 ..	17 0 0	dec. 10/-
,,	9 ..	17 5 0	inc. 5/-

A COMPARISON OF CAST-IRON SCRAP PRICES

Average Monthly Prices of Cast-Iron Scrap in the Principal Districts in the Years 1932-38

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
SCOTLAND (Heavy Machinery)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1932..	2 15 0	2 15 0	2 12 6	2 10 6	2 7 6	2 5 3	2 4 5	2 3 10	2 4 10	2 4 4	2 4 0	2 4 8	2 7 8
1933..	2 7 0	2 9 3	2 10 8	2 10 5	2 9 5	2 9 3	2 8 6	2 10 9	2 10 4	2 10 7	2 10 10	2 12 4	2 9 11
1934..	2 14 2	2 17 9	2 18 5	2 18 3	2 15 5	2 15 9	2 14 3	2 15 0	2 15 9	2 15 0	2 15 8	2 16 3	2 16 0
1935..	2 15 5	2 15 8	2 15 10	2 16 4	2 16 10	2 17 0	2 16 9	2 17 0	2 17 0	2 16 11	2 19 11	3 2 7	2 17 5
1936..	3 4 8	3 9 10	3 10 11	3 11 10	3 10 8	3 9 10	3 9 2	3 8 9	3 8 11	3 9 2	3 10 0	3 13 3	3 9 9
1937..	3 15 0	4 2 10	4 6 2	4 9 9	4 14 9	4 15 0	4 15 0	4 15 0	4 15 0	4 15 6	4 15 0	4 13 3	4 11 0
1938..	4 11 3	—	—	—	—	—	—	—	—	—	—	—	—

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
N.E. COAST (Heavy Qualities)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1932..	2 6 3	2 5 8	2 3 0	2 0 8	1 19 0	2 1 0	1 15 9	1 15 6	1 15 6	1 15 6	1 17 4	1 19 10	1 19 7
1933..	2 1 1	2 2 2	2 4 9	2 3 5	1 18 9	1 19 6	2 0 0	2 0 0	2 1 3	2 5 8	2 7 10	2 10 1	2 5 4
1934..	2 12 7	2 15 1	2 13 7	2 11 6	2 11 11	2 13 9	2 11 0	2 10 6	2 11 3	2 11 10	2 13 9	2 13 3	2 12 4
1935..	2 12 2	2 13 0	2 12 7	2 13 0	2 12 9	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 16 10	2 12 10
1936..	3 0 0	3 1 10	3 1 8	3 2 2	3 4 6	3 3 9	3 5 9	3 4 1	3 5 11	3 6 3	3 6 3	3 7 10	3 4 2
1937..	3 10 6	3 14 9	4 2 6	4 3 9	4 6 3	4 7 6	4 7 6	4 7 6	4 6 0	4 5 0	4 5 0	4 5 0	4 3 5
1938..	4 5 0	—	—	—	—	—	—	—	—	—	—	—	—

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
S. WALES (Heavy Cast Iron)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1932..	2 7 2	2 6 8	2 6 4	2 5 0	2 4 8	2 0 8	1 19 4	2 1 7	2 1 10	1 18 10	1 19 8	2 2 1	2 2 0
1933..	2 3 4	2 4 6	2 4 6	2 4 1	2 3 5	2 2 8	2 3 7	2 4 2	2 5 8	2 5 9	2 5 7	2 5 0	2 4 5
1934..	2 6 10	2 8 9	2 7 8	2 7 6	2 7 6	2 8 0	2 6 10	2 6 7	2 8 0	2 8 2	2 9 1	2 11 5	2 7 1
1935..	2 11 3	2 11 4	2 11 1	2 11 3	2 12 0	2 11 1	2 11 1	2 11 0	2 12 2	2 13 10	2 14 5	2 14 8	2 11 9
1936..	2 16 3	2 18 7	2 18 9	2 19 2	2 18 7	2 18 7	2 19 0	2 19 0	2 18 9	2 19 0	2 19 2	2 19 0	2 18 8
1937..	3 4 1	3 9 8	3 9 3	3 9 0	3 9 0	3 9 0	3 9 0	3 9 0	3 8 9	3 9 9	3 9 9	3 9 11	*3 8 10
1938..	3 10 0	—	—	—	—	—	—	—	—	—	—	—	—

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CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.
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PIG IRON
REGISTERED TRADE MARK
FOR EVERY TYPE OF CASTING
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FERRO-SILICON—FERRO-CHROME
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CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.
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SITUATIONS VACANT AND WANTED

FOUNDRY MANAGER, aged 32 years, desires change. Considerable experience of ferrous and non-ferrous metallurgy; also modern machine methods. First-class record with reputed firms.—Box 786, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY MANAGER.—Steel and Iron. (Metallurgist.) Excellent records reorganising and development; also technical and business experience. Tropenas and Electric. Present output 250 tons monthly.—Box 772, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

ASSISTANT FOREMAN required for modern jobbing iron foundry in the North Country. Capacity 60-70 tons per week. Must be used to modern methods and high-quality general engineering castings. Write giving full details of experience, age, and wages expected to: Box 778, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

CHEMIST required for Blast-Furnace Laboratory, pig-iron, slags, ironstones, etc. Give age, experience, salary, and when at liberty to: MANAGER, NEW CRANSLEY IRON & STEEL CO., LTD., Kettering.

FOUNDRY FOREMAN required for North of England. Excellent opportunity for a good man to take charge of foundry. Must be energetic and thoroughly familiar with the operation of moulding machines. This is a real man's job and can be made very remunerative. —Apply GENERAL MANAGER, Box 780, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

LEADING Hand required ironfoundry, used to heavy and medium castings, jobbing work. Excellent prospects for good man not over 45 years of age. Full particulars and wages required to: Box 790, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

REPRESENTATIVE required, active, and with connections to steelworks, etc., for the sale of Blacklead, etc., by German firm.—Reply to Hamburg 8, Postfach 1282.

WANTED, to go abroad, Foreman Moulder, with experience iron and electric steel castings. Should be good organiser, and well up in the latest methods.—Box 792, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

FOREMAN PATTERNMAKER desires re-engagement. Considerable experience as journeyman and foreman on wide class of work, including valve, machine tool, marine and steel castings. (319)

BUSINESS FOR SALE

IRONFOUNDRY in the Midlands, ideal for machine moulding, equipped as such. To let or to be sold.—Apply Box 794, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FINANCIAL

ADVERTISER is desirous of disposing of interest in Foundry Requisite Business having excellent connection Great Britain and abroad. Reasonable terms can be arranged. Reason for disposal—interest in other business. —Write Box 788, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

TENDER

COUNTY COUNCIL OF MIDDLESEX.

PUBLIC ASSISTANCE DEPARTMENT.

TENDERS FOR FIREBARS AND FURNACE CASTINGS (TWELVE MONTHS).

THE County Council of Middlesex invites Tenders for the supply of the above goods or materials for the period stated from April 1, 1938, to its several Hospitals, Institutions, Sanatoria, Children's Homes, Offices, etc.

Forms of Tender (upon which only Tenders will be considered) and Conditions of Contract may be obtained on application to the Director of Public Assistance, 3, Central Buildings (Fourth Floor), Matthew Parker Street, Westminster, S.W.1, accompanied by a stamped addressed foolscap envelope.

Sealed Tenders, marked "Tender for .....," must be delivered at or before 11 a.m. on Monday February 28, 1938, addressed to "The Clerk of the Middlesex County Council," "P.4." Guildhall, Westminster, S.W.1.

The Council does not bind itself to accept the lowest or any Tender, and reserves the right to accept any Tender or part only.

Estimated quantities required are stated in the Form of Tender, and tenderers may tender to supply all or any one or more of the Establishments concerned.

C. W. RADCLIFFE, "P.4."
Clerk of the County Council.

Guildhall,
Westminster.
February, 1938.

MACHINERY

SANDBLAST PLANTS.

ROOMS size, 12 ft. by 12 ft., 12 ft. by 9 ft., and 6 ft. by 6 ft.
Barrels: 54 in. by 36 in.; 36 in. by 30 in.; 30 in. by 20 in., etc.
Cabinet: 6 ft. by 4 ft.; 4 ft. 6 in. sq. by 3 ft. 6 in. sq., and 30 in. dia.
Table: 9-ft. Guttman.
Air Compressors in stock to suit any of the above plants.
Sand Mills: 7 ft. 6 in., 7 ft., 6 ft., 5 ft. and 4 ft. dia. pans.
Cupolettes: 10 cwts., 15 cwts. and 20 cwts.
Cupolas: 2 and 3 tons.
Morgan Tilting Furnaces: 250 and 400 lbs.
Heavy D.E. Grinding Machine: wheels 24 in. by 4½ in.
Sand Rammers, Disintegrators and Mixers. Air Compressors, Blowers and Exhaust Fans. Moulding Machines, etc., etc.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.
CROSSWELLS ROAD (Adjoining Railway Crossing), LANGLEY, Nr. Birmingham.
'Phone: Broadwell 1359.

THOS. W. WARD LTD.
HYDRAULIC PRESSES.

80 tons cap. WILD press; 10" dia. ram; 2,240 lbs. press. per sq. in.
60 tons cap. TANGYE press; 7" dia. ram; 2' stroke; 3,360 lbs. press. per sq. in.
HOLLINGS & GUEST—50 tons cap.; 8" dia. ram; 2,240 lbs. sq. in. pressure.
Write for "Albion" Catalogue.
ALBION WORKS, SHEFFIELD.
'Grams: "Forward." 'Phone: 23001 (10 lines).

MACHINERY—*Continued*

WANTED.—Crane Ladle, in good condition, 9-10 tons capacity. Detailed description and price to: Box 774, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY HAND CRANE for disposal, about 3 tons lift, 30-ft. span, in good condition; £35. Foundry Sandblast and Foundry "Tubs," also Moulding Boxes.—ALEX. HAMMOND, 14, Australia Road, Slough.

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & CO., LTD., Station Works, Ecclesfield, Sheffield.

CONTENTS Small Iron Foundry—10/15-cwt. Cupola, complete with blower and raising loading platform; Sand-mixing Machines; Core Oven, Moulding Boxes; Tilting Oil Crucible; Oil Tanks.—SURREY ENGINEERING, 226, Whitehorse Road, Croydon.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

'Phone **98** Staines.

2½- and 1½-ton Morris Overhead Hand Cranes, 22- and 20-ft. span.
Air Receiver, 18 ft. by 4 ft. 6 in.
Tilghman B.D. Compressor, 130 c.f. at 100 lbs.
Vertical Crosstube Boiler, 8 ft. 8 in. by 4 ft., 80 lbs. w.p.
HARRY H. GARDAM & CO., LTD., STAINES.

MISCELLANEOUS

PATTERNS.—Cleghorn & Co. have new premises at 198-200, Bath Road, Worcester, and are in a better position to cope with all classes of engineers' pattern. 'Phone 264.

PLUMBAGO—Our different grades will serve you well and prices are right. Our STANDARD Nos. 1 and 2 at 18s. and 16s. cwt., carriage paid, have a large sale. TRY IT and save money.—WM. OLSEN, LTD., Hull.

FINEST FOUNDRY BLACKINGS AND FACINGS. Pure Ceylon Plumbago (Import direct), Finest Core Gum, White Dust. Parting Powder (Silica free), Pure Ground Carbon and Electrodes. Quality at reasonable prices. Orders repeated. Send for free sample.
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PENNINE WORKS,
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A.C. Motor-driven Portable Sand Riddle .....Price £15
SANDSLINGER with A.C. Motors, portable type; in stock.
CORE-STOVE, small size, with swinging shelves.
SAND MILL by Smedley Bros., 4' 3" diam. pan.
NEW 4-ton LADLE with enclosed gears .....Price £38
MORGAN 600-lbs. oil-fired crucible furnace; modern type, as new. Price, £75
Large stock of MOULDING BOXES.
Please send for lists.
ALEX. HAMMOND, *Foundry Machinery Merchant.*
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BUY FROM ME AND SAVE MONEY!